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Tank fires, like this at Casey, Illinois, are a serious cause of loss of oil.

CONSERVATION OF OIL AND NATURAL GAS.—[See page 315.]

# Fiords in Relation to Earth Movements*

## Cracks Produced by the Warping of the Earth's Surface

By Prof. J. W. Gregory, F.R.S.

Fiords have been a powerful influence on modern life, for the existing facility for intercourse oversea is the difference between modern and mediæval Europe which penetrates most deeply into all departments of life and work. The Roman Empire was held together by its roads, and as its conquerors from the wide plains of the east were neither sailors nor roadmakers, Europe was resettled on national instead of on imperial lines. While Europe thus fell naturally into independent States, the most efficient of all means of international communication was being developed on the shores of Scandinavia; for owing to the fiords travel overland there was even more difficult than through the forest-clad plains of Central Europe. In Norway the fiords were the only practicable highways, and they, with their labyrinth of smooth waterways, their tidal currents, which carried boats to and fro independent of wind or oar, and their unfailing supplies of food, fuel, and skins, attracted men to the sea as much as the barren highlands repelled them from the land.

The poverty of their own country having driven the Norsemen to the sea, the wealth of the more fertile southern coast-lands tempted them to the career of piracy which made the berserkers the terror of the shores of western Europe. These pirates, however, amply repaid their debt by their contributions to modern seamanship, made in consequence of the geographical conditions of the Norwegian fiords. Eva Nansen's song contains a true statement of the influence of the fiords on the Norwegian race:

Our mother, weep not! it was thou
Gave them the wish to wander;
To leave our coasts and turn their prow
T'wards night and perils yonder.
Thou pointed'st to the open sea,
The long cape was thy finger;
The white sail wings they got from thee;
Thou canst not bid them linger!

The white sails of the Norse and Danish Vikings, among other things, carried the name fiord far and wide. It is found on the Irish coast, for example, in Wexford, which is said to be derived from the Danish Weis-fiord, and in Waterford from Vadre-fiord; and the name is now accepted as a technical term in general geographical nomenclature.

The word fiord is used in Norwegian for any arm of the sea, including various types of gulfs, bays, and straits. But the name is adopted in international geography for arms of the sea of a special kind. A fiord in this restricted sense is a long inlet which extends far inland between steep parallel walls; it usually consists of long straight reaches, which are bent and receive their tributaries at sharp and regular angles. Its walls are high, as fiords are restricted to mountain regions.

Fiord districts combine the features of mountain and coastal scenery. Many authors have been impressed by a sense of the monotony of fiord scenery, owing to the constant repetition of the same form; it is, however, popular from the easy access to it along smooth waterways, the especial beauty of the cloud forms and the color effects, which do not pass with the flash of a tropical sunset, but last for hours in the prolonged twilight of most fiord areas. The charm of fiord countries is, moreover, enhanced by the survival, owing to the special geographical environment, of primitive conditions of rural life.

The origin of fiords has given rise to prolonged controversy. The difficulty of the problem is due to the peculiar combination of geographical characters. The fiords are clearly valleys, of which the lower ends have been drowned by the sea. Sea-drowned valleys are of three main kinds.

The most familiar kind is that of ordinary river estuaries, which have been submerged by subsidence of the land. Such estuaries have gentle, rounded slopes and curved shore lines; they are typically funnel-shaped, as they increase seaward, both in width and depth. The Firths of the Tay and Forth, the estuaries of the Thames, Severn, and Humber, and Bantry Bay in southwestern Ireland are examples of such drowned valleys. They are well illustrated in northwestern Spain, where they are called rias, and this term "ria" has been adopted as the technical name of this kind of drowned valley.

The members of the second group are known as "fiards" from their typical representatives in southwestern Sweden. They agree with rias by having curved lines, gentle slopes, and indented shores. They differ, however, from rias, as they often include deep basins, separated by rock bars from the outer sea, which may not for some distance reach the depth of the inner basins. Fiards, moreover, usually have no large rivers draining into them, and may receive only insignificant streams and brooks. Fiards are due to a lowland area with an irregular surface of hard rocks having been partially submerged beneath the sea. The essential difference from fiords is that fiards are characteristic of the coast lands which rise to but a slight height above sea-level.

The third group consists of the fiords, which, seen from a steamer or on an ordinary map, have seven chief characters.

1. They are typically long, straight, narrow channels, and they are usually so crowded and run so far inland that they add greatly to the length of the coast line. Thus, whereas in Norway the length of the coast from headland to headland is 1,700 miles, the actual length of the shore line along the fiords is 12,000 miles.

2. The walls are typically high and steep.

3. The fiord channels usually have parallel sides, and the fiords bend or branch at sharp angles, and the same angle tends to recur throughout a district. There is accordingly a striking parallelism in the geographical elements of neighboring fiords.

4. The fiord valleys are often arranged along intersecting lines like a network of cracks, in contrast to the converging tributaries of a river system.

5. The fiords are characteristic of dissected plateaus. All the great fiord districts of the world were formerly plateaus.

6. Owing to the plateau structure the land extends backward from the fiord walls with gentle slopes and shallow valleys. Streams flow gently across these uplands until they reach the fiord wall, and then plunge down it in great waterfalls, which are especially picturesque in spring, when the rivers are flooded by the melting snow. The highest waterfall in the world, the Sutherland Falls of New Zealand, sometimes leaps, it is said, in one jump of 1,900 feet on to the floor of the fiord valley of Milford Sound. The upland valleys which join the fiords have not been cut down to the level of the main valley, but enter abruptly high upon its side. They are therefore "hanging valleys."

7. Finally, the amount of land beside the fiords suitable for cultivation is usually limited to small tracts at the head of the fiord or on small deltas along its sides. The amount of cultivable land in a fiord district is small, and fiord countries are therefore sparsely populated. One of their main values will be as the playgrounds for more crowded countries. They sometimes have rich mineral deposits, as in Alaska; but many American authorities claim that even there the scenery will prove the most valuable economic asset.

The previous characters can be observed by a tourist from the deck of a steamer, but if we could remove the sea and travel over the fiord floors three fresh geographical features would be revealed.

The walls which rise high above the sea surface would be seen to descend steeply to extraordinary depths. The deepest known fiord is the Messier Channel, in Patagonia, which reaches the depth of 4,250 feet. The Sogne Fiord is the deepest in Europe, with the depth of 3,780 feet. Some of the lakes which may be regarded as inland extension of fiords are also surprisingly deep. Thus Lake Morar, in the western Scottish Highlands, of which the surface is 22 feet above sea-level, is 1,017 feet deep; and this fact is all the more striking as the sea to the west does not reach that depth within the distance of 120 miles.

The deepest part of a fiord basin is usually at some distance from the sea; the floor rises seaward until it is covered only by shallow water, or projects above the surface and the fiord becomes a lake.

Fiords are therefore often separated from the outer sea by submerged thresholds. This fact was first discovered by Capt. Cook in Christmas Sound, Patagonia; he found to his danger that on passing up that fiord he lost the anchorage which he had at its mouth. The existence of a threshold is such a frequent feature of fiords that it is regarded by some authorities as an essential character.

The removal of the water from a fiord would show that it has a flat floor. The valley is trough-shaped, whether empty or partially filled with water. The flatness of the floor can be learned by cross sections from charts, or seen on the floor of the undrowned part of a fiord valley.

The problem presented by fiords is therefore that of the formation of systems of steep trough-valleys, which are arranged in networks so that the land beside them is broken up into rectangular blocks, and usually have deep inner basins separated from the sea by shallow thresholds.

The simplest explanation of valley formation is excavation by rivers; but this process will not explain the origin of fiords. Thus our British fiords, the Scottish sea-lochs, are not on river valleys; of the chief Scottish rivers, the Tay and the Forth enter the sea through rias; the Clyde discharges into a compound basin which is not a fiord; and the Tweed, Dee, Don, and Doon have no long arms of the sea at their mouths. The chief sea-lochs, on the other hand, receive only small streams. The rivers systems of Scandinavia, North and South America, and New Zealand show the same independence of the fiords. The fiords are not the outlets of the main rivers. In fact, so far from fiords being made by rivers their existence depends on the absence of rivers, which would convert them into ordinary valleys by wearing back their banks and filling the main channel with sediment.

The failure to explain the formation of fiords by rivers of water therefore led to the invocation of rivers of ice, and many features of the fiord valleys are consistent with their formation by glaciers. The essential difference between the action of water and ice as agents of excavation depends on their difference in plasticity. Water, being very plastic, readily adapts itself to the irregular resistance of the adjacent rocks; it glances lightly off opposing hard surfaces and carves for itself sinuous channels.

Glacier ice flows around opposing obstacles, but as it is less plastic than water it is deflected less readily and bears with persistent pressure against the rocks in its path, and if armed with stones and grit it wears away the rocks like a grindstone. Therefore, whereas denudation by water tends to develop rounded surfaces with curved lines, ice, when confined in valleys, tends to produce straight lines, flat slopes, and angular, facetted surfaces.

The difference between the rounding action of water and the facetting action of ice may be illustrated by reference to the typical forms of pebbles in deposits laid down by rivers and by ice. The typical river pebble is rounded, and often egg-shaped. The typical ice-worn rock in a boulder clay has flattened surfaces, which often meet sharply along straight edges, like the facets of a gem. The same differences can be recognized on a larger scale in the topography of a glaciated district.

Further, a river flows around the base of the spurs from the sides of its valley, and often tends to lengthen them, whereas ice slowly cuts away the toes of these spurs until they end in triangular facets. These facetted ends are well shown on many of the spurs that run down to the Alpine glaciers, and they can be recognized on many Scottish mountains and valleys.

A glacier flowing down a valley presses against the spurs from the two sides and gradually rubs them away. It thus converts a sinuous river valley into a straight canal-like or trough-valley, which is the characteristic form of fiord valleys, of many glacier valleys, and of some of the lower Swiss valleys, such as that of the Rhone—though it is not the usual form of the higher level Alpine valleys from which glaciers have retreated.

This is also an important difference between the powers of ice and water in deepening their valleys. A river, except where it plunges over a waterfall, cannot deepen its valley lower than the outlet. Deep rock basins can only have been made by river action by a combination of three processes; first, the elevation of the country high above sea-level; secondly, the cutting of deep valleys by rivers; and thirdly, the uneven subsidence of the land, so that the mouth of the valley either sank slightly or remained stationary, and was thus left as a raised threshold. The existence of deep fiord basins and their thresholds cannot, however, be thus explained in many and in perhaps the majority of cases.

Ice, however, has greater powers of irregular vertical excavation than water. It moves slowly, and its great weight presses heavily upon its bed. Fragments of the loose material beneath the ice may be frozen into the sole of the glacier and be thus carried away. There is much evidence that the power of a glacier to cut away fresh, undecayed rocks is limited, except where they project into the path of quickly moving ice; but ice acting on weathered, decomposed rock can pick it up and remove it grain by grain. Mining experience shows that the depths to which rocks are weathered varies very irregularly; along the outcrop of a lode there may be a succession of places where decomposition has gone deeply, separated by ridges of fresh and hard rock. A glacier has greater powers than a river in

* Abridged from a lecture delivered to the Midland Institute of Birmingham and published in *Nature*.

eating out such weathered material, and thus forming rock basins.

The attack of glaciers on the rocks beneath them is aided by a second process. Many geologists hold that rivers owe their main power of cutting down hard bars of rock to pot-hole formation, which beneath a river cannot extend deeply below sea-level; but there is no such limit to the depths to which pot-holes are bored beneath a glacier; a stream of water plunging down a glacier mill may drill pot-holes into hard rocks deep below sea-level, and where many occur together the surface may be lowered into a rock basin. Hence glaciers have some powers of hollowing out basins greater than those of rivers. There are, however, other factors which counteract this process, and cause slowly moving glaciers and sheets of snow and ice to protect their beds, for the rock beneath them is preserved from the wear and tear of wind and water, from shattering by heat and frost, and from atmospheric decomposition.

The distribution of fiords has also been claimed as proof of their glacial formation. There are nine main fiord districts in the world, and of these the most famous are in high latitudes and in districts which were formerly occupied by ice. Thus in Europe they occur in Norway, Scotland, Iceland, and Spitzbergen. In America they are found in Greenland and down the western coast throughout Alaska and Canada. They disappear further south, and reappear again in the far south of South America in areas where glaciers still exist upon the mountains, and there is clear evidence of the former extension of the glaciers to sea-level.

The famous fiords of New Zealand are in the southwestern corner of the country, where the glaciers formerly reached sea-level; while the North Island, where, according to many New Zealand geologists, there is no satisfactory evidence of low-level glaciers, has no fiords.

It is therefore claimed that fiords are limited to countries that have been glaciated, and that their restriction to such regions is proof of their glacial origin. Nevertheless, in spite of its attractiveness, the simple theory which explains fiords as due to the action of glaciers appears inadequate. Many fiords were no doubt occupied by ice, and have been molded to their present form by ice; but they were not necessarily formed by it. Fiords are not limited to formerly glaciated areas, and even in glaciated countries their distribution is inconsistent with their glacial formation. Thus a sheet of ice covered nearly the whole of the British Isles, and, according to most authorities, it extended as far south as the line between the estuaries of the Thames and the Severn. The fiords of Great Britain are, however, almost limited to western Scotland, although the ice covered most of the eastern coasts, and there flowed over rocks of the same character as those beside the western fiords. Some of the glaciated areas in eastern England consist of soft beds, upon which glacial erosion should have been particularly effective. Nevertheless, there are no fiords in Yorkshire, for example, although the hills that reach the coast were buried under deep ice, and are composed of comparatively soft rocks. The best English fiords are in Cornwall, where some of the harbors, like those on the opposite coasts of Brittany, have many characters which show that they were originally true fiords; and Cornwall is one of the few English countries which admittedly were not glaciated.

Moreover, the plan of the fiord system in each country does not appear to be that which would have developed as the result of glacial erosion. The chief fiord systems in the world have the same essential plan. Each fiord area is long and curved; in most cases a series of channels extend along the coast, and from them other fiords run inland, and are usually connected by others, or by deep valleys, so that the country is divided into angular blocks.

These networks are not the arrangement that would be expected if fiords had been excavated by glaciers, for in that case the main channels should be radial from the chief centers of snow fall. The course of the fiords is inconsistent with the lines of flow of the chief glaciers. The glaciers discharged from the highlands or from great domes of snow which sometimes formed on the lee side of the existing watersheds; the ice flowed by the most direct channels to the nearest low land or the sea. Many of the fiords owing to their directions were quite useless to the outflowing ice; they appear to have been simply filled with stagnant ice, and the main flow of the glaciers was above and across them.

The inconsistency between the direction of the lochs and the lines of flow is well shown in many parts of Scotland, as, for example, by the map of the ice movements in the area around Colonsay in a recent Scottish Survey memoir. It is also well shown in the Shetland Islands, where the main fiords, lochs, and other geographical elements trend north and south; but the ice movement was from east to west at right angles to the fiords.

The final and most convincing argument against the glacial origin of fiords is that they are pre-glacial. They are older than the ice which once occupied them. They are due to a series of uplifts which happened mainly in Pliocene times after the great Miocene movements which in Europe formed the Alps and the associated mountain chains. In nearly all cases the fiord valleys were formed in Pliocene times; hence the Pleistocene ice used the fiords and did not originate them.

It is therefore necessary to find an explanation of these complex valley systems independent of the ice action, which has given some of them their most conspicuous features. Facetted spurs and long parallel-walled valleys with hanging valleys upon their sides are formed by other than glacial agencies. They may be due directly to earth movements, as in the fiords of Dalmatia. Thus the famous fiord of Cattaro is flanked by facetted spurs, and the formation of the facets is due to recent faulting. The straight Dalmatian trough-valleys with their high walls and hanging valleys are due to recent earth movements, aided by the comparative weakness of the rivers owing to the porosity of the limestone which is the prevalent rock. These fiords are due to the earth movements which formed the Adriatic Sea, and all the fiord systems of the world are related to earth movements. Their networks do not resemble valleys cut by erosion, but intersecting fractures. The most striking features in the distribution of fiords connect them not with ice movements, but with earth movements. The fiord systems of all parts of the world are arranged, not in radial lines from the highlands, but as angular networks resembling intersecting cracks in slabs of twisted glass. This fact is apparent from Kjerulf's plan of the fiords of southern Norway, which showed that all the fiords, lakes, and main valleys of that country can be arranged into a number of groups each with a definite direction, and the different series cross at sharp angles. The same arrangement of the fiords on intersecting lines is shown in Alaska, Patagonia, New Zealand, and Scotland.

The Scottish lochs and their valleys may be arranged in four groups. The most conspicuous lines in the coast of Scotland run east and west, as in the Pentland Firth and the southern side of the Moray Firth. Many of the western lochs, such as Loch Hourn, Loch Leven, Loch Eil, Loch Rannoch, and Lower Loch Etive, trend in this direction, which also occurs in the northern coast of Connaught in Ireland, and along the northern coast of Wales.

The second series of lines trend north and south at right angles to the first.

The members of the third group trend northeast and southwest; they include Glen More, the line of the Caledonian Canal, the Kyle of Tongue, the valley of the Spey, Upper Loch Etive, Loch Awe, Loch Fyne, many of the lochs around the Sound of Jura, and the central part of Loch Tay.

The direction of the fourth group is at right angles to part of the Glen More lines, and its series of valleys and lochs extend northwest and southeast, and include Loch Broom on the northwestern coast and Lower Loch Fyne and Loch Crinan, and the Sound of Islay; also various inland lakes, such as Loch Shin.

These directions are not those that would be expected in valleys formed by glacial erosion. The largest center of glacial accumulation in Scotland must have been the Grampians of eastern Aberdeenshire, for though the highest point of the area around Ben Macdhui and Cairngorm is slightly lower than the summit of Ben Nevis, it belongs to the largest area of highlands in Scotland. All this land was unquestionably covered by ice, and in no part of Scotland are glacial phenomena better displayed. Most of the ice probably flowed eastward and northeastward and reached the North Sea; but nowhere along the eastern coast are there any fiords, and in spite of the great power of the glaciers, even the long narrow fresh-water lochs are confined to western Scotland.

Ben Nevis was also intensely glaciated, and the chief ice movements in that area were from southwest to northeast, for the great center of accumulation was over the country between Ben Nevis and the coast, owing to the heavy precipitation of snow piling up a huge ice dome. Valley glaciers radiated from Ben Nevis in the last stages of the glaciation, but the chief lochs in this district are not radial from Ben Nevis, but form a circular series around it.

The angular fiord networks also occur in regions where there are no indications of the former existence of glaciers. Thus the colony of Hong Kong, including the adjacent peninsula on the mainland of China, has a fiord-like series of intersecting valleys, and a most beautiful example of the same arrangement occurs in the peninsula of Sinai. The Gulf of Akabah has many of the characters of a fiord, and Prof. Bonney has so called it; and, if Sinai were partially submerged, it would be divided into angular islands and peninsulas, separated by parallel-sided, steep-walled valleys, which would form a typical series of fiords.

The explanation of fiord valleys as due to intersecting fractures explains the chief facts of their distribution. It explains their restriction to plateau countries, as it is only where wide areas have been uplifted that they are shattered by regular intersecting cracks. It also explains their restriction to areas of old rocks, for the younger rocks yield by stretching not by cracking.

The fiord valleys were not formed by gaping cracks of the full width of the present valleys. The cracks caused narrow clefts along the planes of weakness, which have been widened by denudation. Water and air enter them and cause the decay of the rocks. Streams remove the weakened rock material, and the clefts are gradually widened into river valleys, and if the country be subsequently glaciated the ice enters the valleys and completes their formation.

Uplift alone is, however, inadequate to produce fiords. Subsidence also is necessary to let in the sea. In nearly all fiord countries the last movement has been a fresh elevation. Many fiord thresholds appear to be due to a tilting of the country at the last uplift.

Fiords, therefore, are produced in regions which have undergone repeated earth movements. They mark out areas of the crust which in recent geological times have undergone alternate elevation and depression. These regions are mainly polar and circum-polar, as in the equatorial zone the uplifts have been more local. There are numerous raised coral reefs, but the tropical coasts of Africa, Australia, and America lack the widespread raised sea beaches which are so characteristic of the chief fiord regions. The restriction of the fiord areas to high northern and southern latitudes gives a clue to the cause of the fiord movements. They may be explained as a deformation of the earth which is more marked in the polar than in the tropical zones. If a flexible circular band be rotated about its axis it becomes oval, and the radial movement is greater on the flattened polar sides than on the raised equatorial zone. The deformation of the earth which produced the fiords caused greater vertical movements in the polar and circum-polar regions than in the tropics, and thus fiords are characteristic of higher latitudes.

I have, therefore, endeavored by this rapid survey of a wide subject to show that fiords are not only attractive from their unique scenery and their special historic interest, but that they give important evidence relating to the structure and mobility of the earth. The spirit of maritime adventure born in the Scandinavian fiords gave the European races the mastery of the sea and a political predominance which is world-wide in its influence. The geological study of fiords leads to geographical problems that are also world-wide in their range, for the view that fiords are due to local superficial agents chiselling out furrows on an impassive earth explains neither their features nor distribution. Fiords teach more significant and far-reaching lessons; they point to deep-seated forces which affect the earth as a whole. However greatly fiords may have been molded by ice, wind, and water, they are not primarily due to those agencies, which have used the fiords, not made them.

The ultimate cause of fiords is the rupture of certain wide areas of the earth by the pulsation of the crust under the play of titanic forces set at work by the great Miocene disturbances which upheaved the chief existing mountain systems of the world.

## Lohmannizing

THE protection of iron and steel is at present effected by means of three zinc coating processes: the old "hot galvanizing" process, the "cold galvanizing" process (electrolytic zinc plating), and the "sherardizing" process. The process of "Lohmannizing," invented by H. J. Lohmann, differs from these in that it is not restricted to the application of zinc coatings, but may, it is claimed, be used for coating of zinc, lead, and tin in varying preparations to suit the requirements of each case.

The process of Lohmannizing begins, as usually, with pickling the iron and steel articles in a bath of sulphuric acid. Then the article is dipped into the Lohmann bath, which, being "composed of an acid and an amalgamated salt, further cleanses the pores and cavities, and deposits metallic salt upon the entire surface, penetrating into the most minute pores and cavities." The patent specification states that the Lohmann bath is a solution of hydrochloric acid, mercuric chloride, and ammonium chloride. Next follows drying and then immersion in the molten protective alloy which is at a temperature of 950 to 1,000 deg. Fahr. "An amalgam or chemical union is thus formed between the amalgamating salt and the protective alloy." The temperature of the immersed article rises in contact with the molten alloy, and, when it reaches a temperature of 500 degrees, volatilization of the mercury occurs. Since the mercury passes from the surface of the alloy, the complete surface is said to be left free and open for the protective alloy to fill its pores and cavities, there being freedom from oxidizing influences. As it is said that it is possible to obtain a perfectly satisfactory lead plating by the Lohmann process, it would seem that the process would be of value in the production of lead-lined apparatus.—*The Journal of Industrial and Engineering Chemistry.*

# Masons' and Other Marks on Saxon Churches*

## Some Disputed Points in Archæology

By Leo L. W. Gaye and Arthur Galpin

The curious markings, frequently found on, or near, the South Porch of pre-Reformation churches—usually from three feet to six feet from the ground (Figure 2)—have puzzled nearly everyone who has noticed them; and a recent visitor to the parish church of Skeyton, in Norfolk (England), wrote to a provincial newspaper, asking if anyone could tell him the origin and use of what he had heard described locally as the "Sun-dial." A correspondence was continued for upward of three months, and showed not only that the subject is interesting to a very large number of persons, but that the utmost confusion exists as to what these "Dials" really are. "Masons' Marks," "Consecration Crosses," "Protractors," and "Sexton's Wheels" were in turn suggested; the only point of agreement being that they are *not* Sun-dials! At the close of the correspondence the writers of the present article began to investigate the subject, and the result of their search for information (in which they have been assisted by clergy and laymen in all parts of Great Britain) has not only proved most interesting, but they have succeeded in answering the original question, "What are these 'dials' and how were they used?"

In considering this subject it is necessary to constantly bear in mind, first of all, the ways of the post-Reformation church restorer. To him is due the "migration of stones," and he appears to have acted upon some such rule as "Here's another stone with something on it; better not throw it away; stick it in *somewhere*; it doesn't matter where" . . . . and in it went! An instance of this is seen at All Saints', Norwich, where five of the original consecration crosses (Figure 8) are now in the *outside* wall! This is also the easy explanation of sundials being found *inside* churches. Secondly, we must remember that the "Reformers" and their immediate successors have left their trace everywhere; scarcely anything which is sacred or even that which is simply ecclesiologically interesting appears to have escaped them. One finds consecration crosses mutilated, "embellished," and duplicated; sun-dials duplicated (more or less faultily) and originals either mutilated or "improved" by added radii, and so on; in fact where the examples are well weathered it is often extremely difficult to distinguish the true from the false.

The suggestion that Saxon dials are consecration crosses found many supporters, but that these were mistaken is easily shown. The consecration of a Catholic church is a most interesting ceremony occupying several hours, and as all the churches directly or indirectly referred to are pre-Reformation, a brief reference to the crosses (Figures 7 to 9 and 11 and 13) will be interesting, and will explain what proved a difficulty to so many persons. There are twelve crosses upon the inside *walls* (not on the pillars or columns), one each side of the main entrance, one each side of the sanctuary, and four upon each side wall They are seven feet six inches from the floor and are sometimes painted upon the walls, sometimes of metal let into the walls, and sometimes cut into the stone (or, if the walls be not of stone, cut into inserted stones). A metal, or wood, sconce (in which a candle is kept burning from the beginning of the consecration ceremony until the church is closed at night, also all day on the anniversaries of the consecration) is fixed above or below each cross. An interesting exception to this is seen at All Saints', Norwich, where the sconces were in the *center* of the crosses (Figure 8) as shown by the remains of the tangs still visible. In the course of the ceremony these twelve crosses are anointed by the bishop with his thumb dipped in holy oil—as sometimes is also a cross on both door-jambs of the main entrance. These two (which are four feet six inches from the ground and have no sconce) are usually, but not always, cut into the jambs; if the jambs are made of brick two small stones (in which the crosses are cut) are let into the bricks. The large number of crosses sometimes found upon door-jambs puzzled many correspondents (one of whom suggested that they are "Institution" crosses, i. e.,

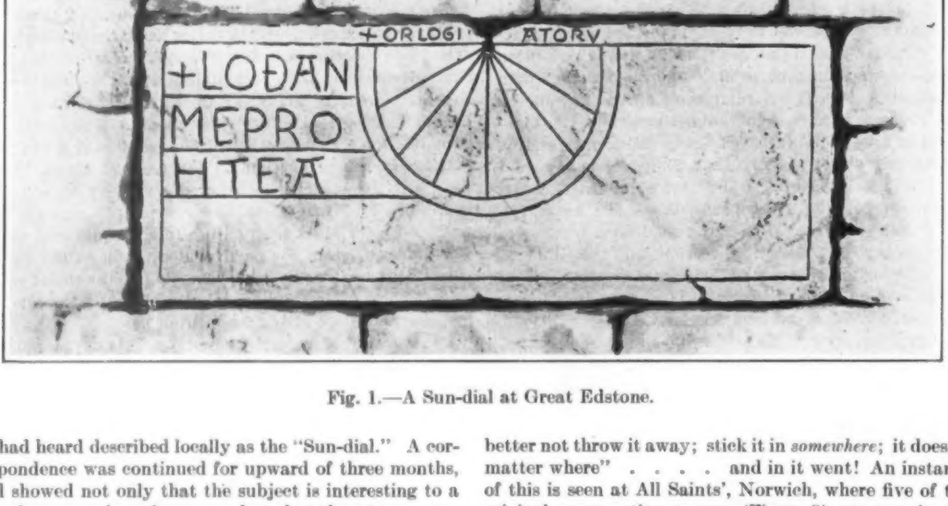



Fig. 1.—A Sun-dial at Great Edstone.

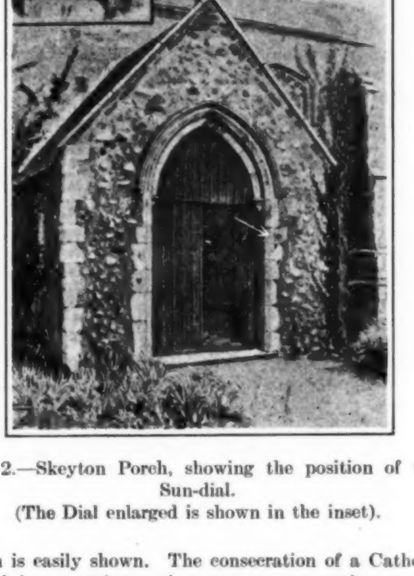


Fig. 2.—Skeyton Porch, showing the position of the Sun-dial.
(The Dial enlarged is shown in the inset).

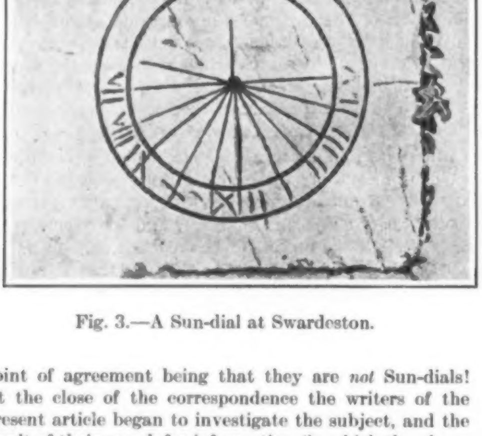


Fig. 3.—A Sun-dial at Swardeston.

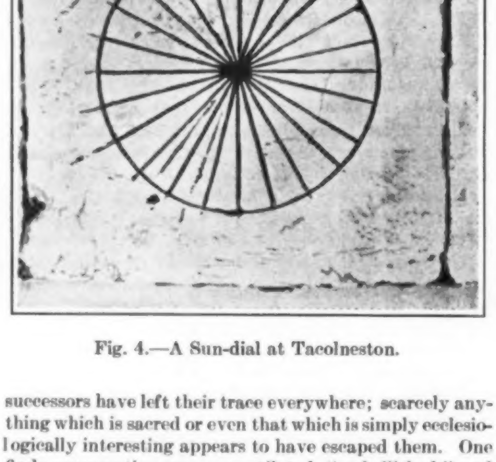


Fig. 4.—A Sun-dial at Tacolneston.

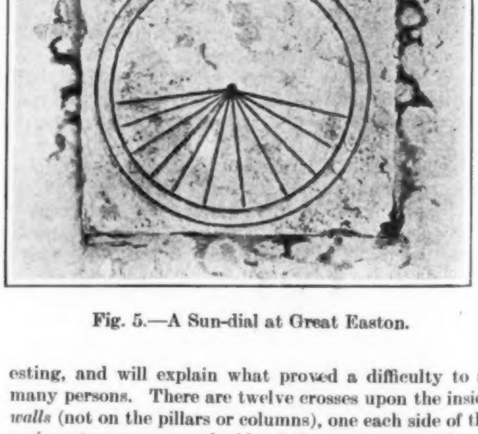


Fig. 5.—A Sun-dial at Great Easton.

* Reproduced from *Knowledge*.


Fig. 6.—A Sun-dial at Kirkdale.

whenever a new appointment was made a cross was cut in commemoration, upon the jambs), but this duplication has been explained when speaking of the "Reformers" as also is the eccentric form some of the original crosses now take.

Those persons who believed the Saxon dials to be "Masons' Marks" were equally mistaken. "Masons'

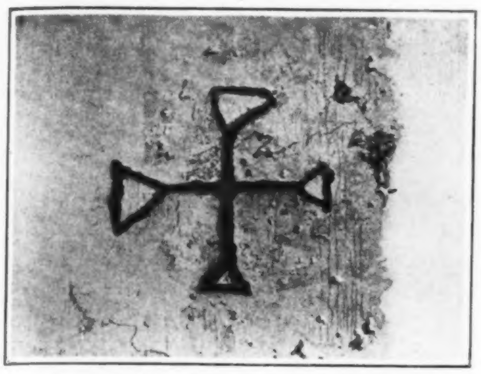


Fig. 7.—Consecration Cross at Rockland, St. Mary.

marks" are so varied and numerous as to be countless; and it is customary for a mason to mark, or "sign," his work, just as an artist signs his picture. The position of the mason's "mark" has varied from time to time. Apparently, at the beginning of the sixteenth century it was customary for a mason to place his "mark" on the back of stone, and not scratch it upon the face of stonework as was done prior to that period. Figures 14 and 15 are the "marks" of two well-known masons at present living in Norwich (one of whom suggests that Figure 10, which is much more frequently met with than most others, is the "mark" of a masons' guild, *not* of an individual mason), and they are shown on the joint and top bed of stonework respectively, these being the positions usually occupied by modern masons' "marks."

It was also suggested that the Saxon dials might be primitive "Protractors" by which masons set their "sliding bevels"! In support of this it was pointed out that the angles at which most stones were cut, were multiples of the angle of 15 degrees intercepted by each pair of radiating lines of the dial marks. However, the "marks" selected for illustration (Figures 10 and 14 to 17), and the many others which have been examined, undoubtedly do away with any justification for entertaining that idea.

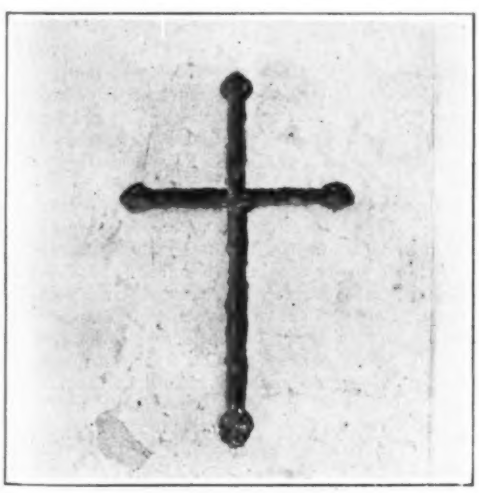


Fig. 11.—Consecration Cross at Kirby Bedon.

Apart from the fact that comparatively few of the marks are described sufficiently accurately to allow one to suppose that they were ever put to that purpose successfully, stones—where accuracy was of any moment—would in all probability have been cut to the required angle before leaving the mason's "banker" or bench, and therefore the existence of such a protractor on the site would not be necessary. A measure of proportion by which the parts of

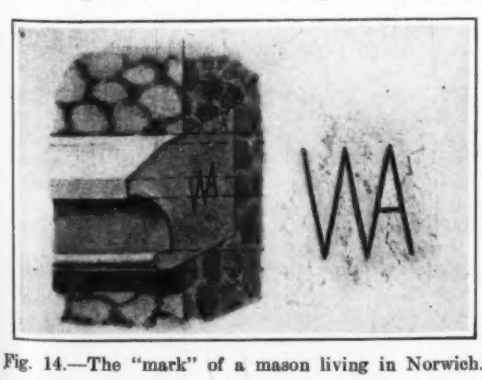



Fig. 14.—The "mark" of a mason living in Norwich.

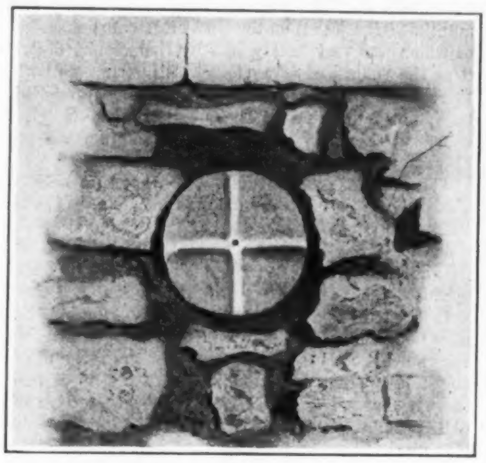


Fig. 8.—Consecration Cross at All Saints', Norwich.

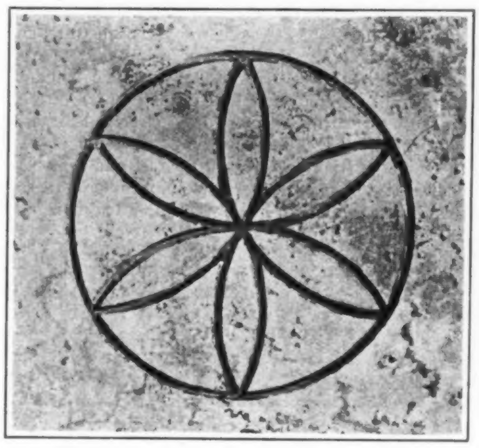


Fig. 10.—Mason's "mark" at Claxton.

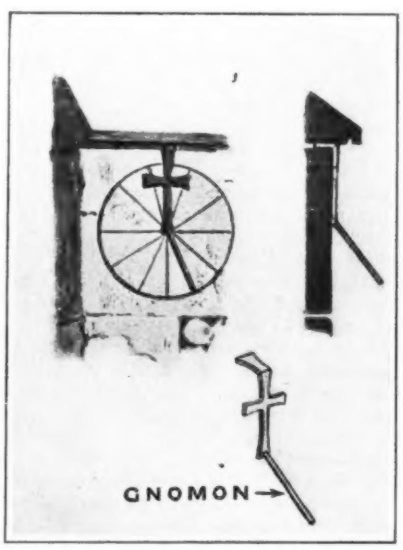



Fig. 12—Mr. Arthur F. C. Bentley's "Conjectural Method of Fixing the Gnomon."

an order or of a building are regulated in *classical* architecture also seemed destined to be confused with sun-dials. The measure in question is termed a "module"; it consists of a diameter or semi-diameter of a column and is divided up into sixty equal parts (termed "minutes"). So far as can be discovered the *circumference* of a column has never been taken as the module, but some persons may have had its division in mind when likening such a scale to a sun-dial.

SUN-DIALS.

The Saxon sun-dials which sometimes have a double and sometimes a single outer circle (Figures 4 and 5) and which sometimes consist of radii without a circle, or semi-circle (Inset in Figure 2), are very much more widely distributed than may be supposed. It has been said that they cannot be *sun*-dials because in very many instances the radii or the spaces cannot be assigned in any possible way to the twenty-four hours of the day. But it must be remembered that "Time" has not always been computed as at present; there have been many quite distinct notations of time, and *our* division of the day into twenty-four hours is comparatively modern. The Saxons divided it into "Tides," each of three hours, and their earliest dials, which are semi-circular (Figure 6) mark four tides (day-time). The circular dials marking eight tides (day and night) came later. At a later period these divisions were sub-divided and, still later, further sub-divided until at last they were brought into conformity

Fig. 9.—Consecration Cross at Skeyton

with the twenty-four hour method. Some persons say "as the sun cannot throw a shadow upward these dials cannot be *sun*-dials," but the reply to this appears to be that having selected the chariot wheel as the shape or form of the sun-dial it was natural to use the complete form even though only the lower half was needed. Apart from that, the complete "wheel" possibly often proved useful in enabling a person to determine the position of the hours at a glance notwithstanding the general absence of figures. But that this was a question of completeness rather than anything else is shown by the Great Edstone, Great Easton, and Kirkdale dials (Figures 1, 4 and 6). The former although circular has only the lower radii cut, both the latter are semi-circles. It has sometimes been said that certain dials cannot be Saxon because they were obviously made at a later period; but the term "Saxon" refers to the notation, not necessarily to the workmanship. The varying spacing of the lines on Saxon dials has been the cause of much perplexity to those who have failed to notice a much greater variation in modern sun-dials, usually owing to the orientation of the building (or, more correctly, the declination of the dial). Churches are invariably built approximately "East and West," but secular buildings cannot always

Fig. 13.—Consecration Cross at Claxton.

be placed according to that rule; therefore the modern sun-dials which are found upon private houses, schools, and so on, vary to a much greater extent than do the Saxon dials found upon churches. Although a very large number of Saxon dials still have the tang of the gnomon

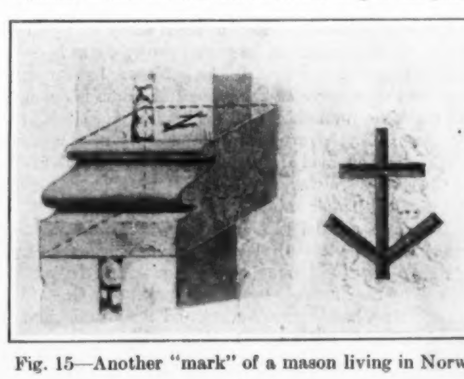


Fig. 15—Another "mark" of a mason living in Norwich.

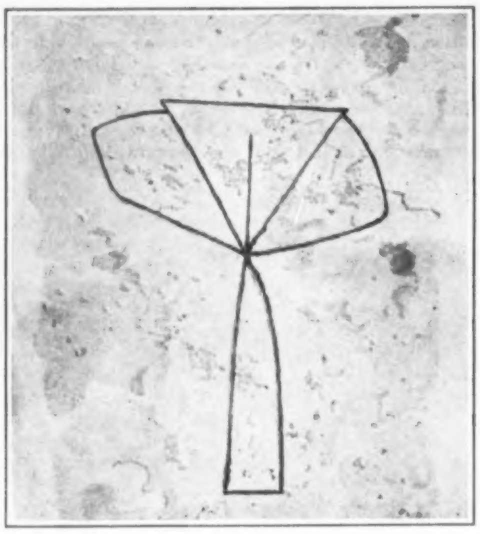


Fig. 16.—Mason's "mark" at Trowse.

embedded in the stone, most careful search has failed to discover one with the original gnomon intact, which is not surprising when their age and exposed position is remembered. Because the tang is horizontal many persons believe the only possible gnomon was a horizontal one, and that therefore the dials cannot possibly be *sun*-dials; but this error is probably the outcome of having heard, or read, the erroneous statement, "The gnomon *must* be parallel to the Earth's axis." (The angle or otherwise of the gnomon makes no difference to the possibility of reading time.) Perhaps the best possible evidence that the Saxon dials *are* sun-dials is afforded by the Great Edstone, Swardeston, Kirkdale (Figures 1, 3, and 6), and Market Deeping dials. In the majority of instances one finds simply a *dial*, i. e., the dial without inscription or figures; but the two former *have* an inscription (indisputably contemporaneous with the dials), and both of the latter have *figures* denoting the hours. In the center panel of the Kirkdale dial the inscription (translated) tells us, "This is Day's Sunmarker at every Tide," and that (translated) on the Great Edstone dial (a sketch of which was very kindly sent by the Rector) describes it as the "Clock of Travelers." In instances, of which there are many, where the radii cannot be assigned to any known notation of time, ecclesiastical (e. g., the canonical hours) or secular, the explanation will probably be that they are due to the "Reformers."

The finding of Saxon dials which have no hole (and obviously never had one) for fixing a gnomon has been claimed as convincing proof that they are not *sun*-dials; but Mr. Arthur Bentley's "conjectural method of fixing the gnomon" (Figure 12), which is reproduced by his kind permission, has most effectually explained that difficulty.

It is interesting to notice how easily Figures 7 to 10 may be mistaken for Figure 5, as all three examples are very much weathered, and a casual observer would probably notice practically no difference. Fig. 5 is one of the Tacolneston dials, Figure 8 is a consecration cross (All Saints', Norwich), and Fig. 10 is a mason's mark (Claxton).

The term "Orientation" previously referred to is frequently misunderstood. It is very usual to say "Churches are built East and West" but comparatively few persons know that very few are due East, and that there is generally quite sufficient variation to make the adjustment of the markings of a sun-dial necessary. The variation is caused in this way: The foundations of a church are laid according to the position of the sun on the patronal feast; therefore a church dedicated to, say, St. John the Baptist (June 24th) is not in exactly the same position with regard to East and West as one dedicated to, say, St. Andrew (November 30th), and this divergence has to be allowed for when marking the lines upon the sun-dial.

Sexton's Wheels (which have been unaccountably confused with Saxon dials) are portable articles, and only two specimens are known to exist, at Long Stratton and Yaxley, both in the diocese of Norwich. They have no connection either in form or use with sun-dials and a very interesting illustrated description of them will be found in "Norfolk Archæology," Vol. IX, 1881.

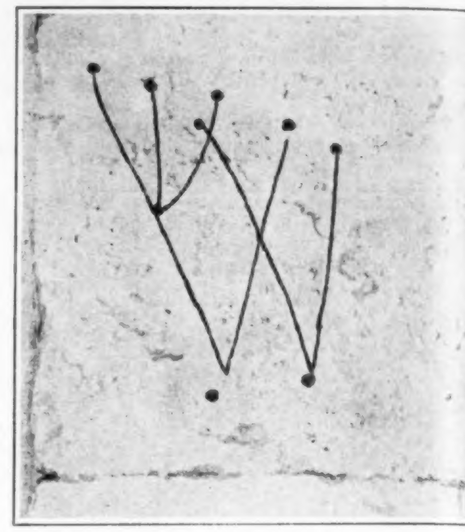


Fig. 17.—Mason's "mark" at Hellington.

The authors are greatly indebted to the large number of persons who have not only corresponded but have gone to considerable trouble in making rubbings, sketches, and so on; especially to Mr. R. H. Flood (who lent a very large number of interesting rubbings), and to Mr. Arthur F. C. Bentley (who most kindly made and presented practical models of four primitive sun-dials, set out for the latitude of Horstead, in Norfolk, and whose "conjectural method of fixing the gnomon" helped them out of what undoubtedly proved one of their greatest difficulties).

# The Complete Artificial Nutrition of Animals*

## Synthetic Food Made in the Chemical Laboratory Proves All-sufficient

FROM the Physiological Institute of the University of Halle comes the announcement of a solution of the problem of the artificial nutrition of animals.

This announcement is in the form of a contribution to Hoppe-Seyler's *Zeitschrift für Physiologische Chemie*, by Dr. Emil Abderhalden, who, as the layman should be informed, is one of the most prominent among living authorities on biological chemistry. This paper of Dr. Abderhalden is the final summing up of a long series of researches which he has carried out with the assistance of many collaborators. The essential fact of this communication is that Dr. Abderhalden has proved to his own satisfaction the possibility of sustaining life and growth exclusively on nutriment prepared in the chemical laboratory from the elements.

To appreciate the significance of this discovery, we must recall some of the current teachings of physiology concerning the nature of food.

There are three classes of substances capable of being used in the nutrition of the higher animals, namely, the carbohydrates (represented by the sugars and the starches), the fats (represented by lard, tallow, butter and olive oil), the proteins (represented by such substances as flesh, white of egg, etc.), and mineral matter (represented by the ash left when food materials are burned). The fats and the carbohydrates are merely food accessories. They supply the organism with heat and energy, while the protein-carrying materials which we get from the butcher and the baker are considered the really indispensable materials needed in the building up of muscle and other vital tissues.

The proteins contain an element of food which cannot be dispensed with—nitrogen. An animal fed exclusively on fats and sugars would soon waste away and perish, whereas all life functions, including growth, can be supported on an exclusive protein diet. Nature has arranged things so that at present the animal kingdom is dependent on the vegetable kingdom for a supply of these fundamentals. In the mysterious laboratory of the plant cells the carbonic acid and water of the air and the nitrogen of the soil are welded into living matter suitable for the use of the higher animals.

Ever since physiological chemistry took on definite form as a science the physiological chemist has been trying to see how far he could go in imitating the results attained by the life processes of living matter. One of his pet objectives has been to understand the chemical basis of food materials with a view to their artificial production, and thereby achieve for man a certain theoretical, if not practical, independence of living nature. As a result of decades of research and investigation, in which some of the most brilliant of living and dead chemists have taken part, chemistry has within its power to make thousands of substances which heretofore it was not thought possible to produce otherwise than by the agency of life.

One of the early triumphs of the chemists in their endeavor to synthesize essential food materials was the manufacture of sugars and fats in the laboratory. If there were no sugar plantations or hog farms the chemists would still be able to provide the nutritive equivalents of cane-sugar and lard, though at an expense so greatly increased that the present high cost of living would seem like free board and lodging in comparison; but there the onward march of chemistry has been halted for a considerable time. The problem of synthesizing proteins still looms up large and baffling, although much promising work has been done by Emil Fischer in his famous study on the polypeptids.

"Will man ever succeed in synthesizing a protein or an albumin like that found in the white of an egg?" Possibly not. Until this task is accomplished it might appear that the problem of artificially manufacturing a complete food will remain unsolved. But the solution of this great problem, the laboratory synthesis of protein, may just as well remain unsolved forever in so far as complete success in the artificial nutrition of animals is concerned. It has now been found that the protein as such are not indispensable to complete nutrition and growth. This is the central fact of the announcement made by Abderhalden on the basis of his successful experiments with dogs.

The proteins as such are not necessary as an element of food. When a typical albuminous food, such as an egg, is taken into the stomach, the first thing that happens to it is that the proteins are broken up by the digestive juices into their proximate constituents, the amino acids. These amino acids in passing through the walls of the intestines into the blood are synthesized into new protein forms suitable for the nourishment and upbuilding of the tissues peculiar to the animal which ate the egg. When the physiological chemist first convinced himself that the proteins must first be broken up into the amino acids, nothing was more natural than that he should ask the question: "Does it make any difference whether the amino acids are introduced into the alimentary canal ready formed or locked up in the form of protein combinations which must be broken down by the digestive enzymes?" This is a question which is eminently adapted to be put to an experimental test. The result of the experiment was to show that the artificially prepared amino acids could be utilized by the organism in synthesizing its protein substances and maintaining its life processes.

Thus one of the great purposes of the chemist has been achieved. Starting from purely elemental matter he can manufacture in his laboratory all that the animal body requires. With a mixture of wholly artificial food substances, such as artificial glucose (representing the sugars), artificial glycerin and fatty acids (representing the normal edible fats), and artificial amino acids (representing the proximate constituents of the proteins), together with a little mineral matter (representing the elements of bone), he can sustain the life and maintain the growth of young dogs, and presumably also of young people, if the latter were obtainable as experimental material. It is thus shown that the food of animals need not necessarily consist of substances previously elaborated by a plant or another animal: the test tube and the beaker have added another field to the great number in which their power has been demonstrated.

Though of the highest scientific interest, the practical results of this truly great discovery are likely to be very small—for a time at least. But Abderhalden sees possibilities of applying the discovery to certain urgent cases in practical medicine. It sometimes happens that the stomach, from the presence of ulcers, has to be operated upon. A prime condition of the healing of any wound requires above all things, quiet; and this is true of the stomach as of a broken leg. But the patient must be nourished during the healing of the wound, and how can a very badly damaged stomach rest if it is continually called upon to digest food which must be taken in order to sustain the patient's life during the period of healing? In such a case the stomach can be temporarily switched out of the alimentary system and the necessary nutriment, in the form of the elementary constituents of protein, introduced rectally. Where the alimentary canal fails to prepare its digestive fluids, a completely hydrolyzed and predigested mixture consisting of the amino acids, sugar and fat can be supplied. The glassware of the laboratory can take upon itself the functions of the walls of the stomach, and that tired organ may be completely relieved of its work.

A fact of prime interest in this connection is that we may at last regard the immediate "physical basis of life" as having been identified. Now that the chemist has finally become acquainted with the "Bausteine"—building blocks, as Abderhalden expressively calls them—which life uses in building its structures, they can be in-

* Reproduced from *Pure Products*.

troduced to the non-technical layman as the essential foundations of his being. They are:

| | |
|---|---|
| glycocoll | d-glutaminic acid |
| d-alanin | l-phenylalanin |
| l-serin | l-tyrosin |
| l-cystin | l-lysin |
| d-valin | d-arginin |
| l-leucin | l-prolin |
| d-isoleucin | l-hystidin |
| l-asparaginic acid | l-tryptophane |

[The letters l and d prefixed to the names of these substances indicates that they are respectively dextro or levo rotatory.]

The various members of this list differ in importance, and if we were to consider only a combination which represents the lowest minimum on which life and growth could be sustained the list could be shortened. Thus glycocoll, while useful and capable of entering into the composition of living matter, is not indispensable. It can be left out of the ration and the animal will thrive as before. On the other hand, l-tryptophane cannot be dispensed with. Any ration from which this substance has been omitted becomes fatally deficient on that account. It yet remains for the physiological chemist to give these substances their final ratings, to determine which are keystones and cornerstones, and which are ordinary components of the side walls of the living structure.

The manner in which these elemental units are superposed one on the other to form the delicate structure of living matter is still unknown. How l-tryptophane and the rest are woven together to form muscle and nerves is an outstanding problem, but we need not doubt that the test tube and beaker, having achieved the breaking up of the protein structures and separating them into their primal units, will proceed calmly to attack the opposite problem of putting them together again to reconstruct the original flesh. There are those who will exclaim that this can never be done; but we should not be too hasty in decrying the possibilities of chemical glassware.

The recognition of the amino acids as the ultimate units of digestion at once explains why various foods differ in food value and ease of digestion. When food is eaten it is "up to" the stomach to demolish the protein structures presented to it and to deliver the second-hand "building stones" to what we may personify as the "physiological masons" stationed in the walls of the alimentary canal. The work of demolition is accomplished in the stomach by the aid of certain tools called enzymes, which may be likened to the crowbars used by building wreckers in prying apart the stones of a building which is to be torn down. If, however, the structure which the stomach is called upon to wreck is of a type to which its crowbars (enzymes) are not at the time adapted, the work of digestion is difficult and prolonged.

As a general rule each animal requires the fundamental amino acids in a tolerably fixed proportion to one another. If the food eaten contains the amino acids in a different proportion, the body is supplied with a deficiency of "building stones" of one kind and an excess of another kind, with the result that the superfluous structural units, in so far as they are not capable of acting as substitutes for the missing units, have to be thrown out. The stomach, like every other building contractor, must furnish building materials of the size and shape called for in the architect's plan. That food will be most completely utilized which is most nearly related in composition, as regards the amino acids, to the bodily substance of the animal which eats it, provided, of course, that the animal's stomach is equipped with suitable enzymes for disintegrating the structures presented to it.

Animal foods, such as eggs, beef and blood, are more completely digested and with less trouble by flesh-eating animals than vegetable substances. The digestion of the latter requires more work because they contain proteins dissimilar to those of the animal body, and they also contain a higher percentage of "building blocks" which cannot fit into the new structure and must therefore be thrown out. We have expressed this heretofore by saying that the co-efficient of digestibility of vegetable foods is smaller than that of animal food. Thus in a sense is beef-loving humanity justified and the thorough-going vegetarians confounded; but a diet which is predominantly of meat is objectionable from its very virtues—it is too apt to provide "building stones" for a structure far larger than is contemplated in the design. The builders are swamped and the orderly work of placing stones hampered by the very excess of material pressed upon the physiological masons.

The patient reader who has followed us thus far will doubtless be interested in a short sketch of how the experiments which have given these results are carried out.

The animal most suitable as a subject for trying doubtful experiments on nutrition is the dog, chiefly because the dog is the animal most friendly to man and the most pliable to man's will in the matter of eating and drinking; but not all dogs will do. These animals have their idiosyncrasies in the matter of diet as strongly marked as the idiosyncrasies of human beings. Particularly unsuitable are well-kept dogs, which are accustomed to good food. The best material is the ordinary street dog, especially terriers. In addition, the dogs must be well trained so as to facilitate the work of weighing and analysis, and on a footing of perfect friendship with the keeper, who is generally the chemist himself.

To keep the dogs in the best frame of mind during these experiments their food must be prepared by their beloved keeper, who also must intrust to no other hands the work of cleaning their cages and in tending the animals generally.

Having procured his dogs and won their affections, the chemist weighs them and takes thorough account of their physical condition. Then the dog is fed on a given substance, or mixture of substances, the nutritive value of which is to be determined. Any gain or loss of weight is carefully noted by frequent weighings. If the dog loses weight it is clear that the food given is deficient in nutrient elements. If his weight does not fall off, or if he gains in weight, this is a clear sign that the nutrient meets the demands of nature.

The food of the animal is exactly analyzed to determine how much nitrogen he is receiving. The feces and urine are also analyzed to see how much nitrogen he is throwing off.

It is of especially great importance when studying protein foods to learn whether the nitrogen balance is positive, negative or evenly maintained. If the nitrogen balance is negative, that is, if the animal is throwing off more nitrogen than is given him, this means that the nitrogen in the food cannot maintain the bodily processes: the substance fed to the dog is deficient in suitable "building blocks." If the outgoing nitrogen balances the ingoing, the normal physiological condition is being kept up; and if less nitrogen is thrown off than is taken in the animal is gaining in weight and the substance being fed contains the "building blocks" in proper proportion and amount.

In this way each separate substance can be examined as to its right to be called a true "building block" of life.

# Natural Sources of Energy

## Taking Stock of Our Supplies and Needs

IN view of the attempt which England has just witnessed to organize a labor trust in the coal trade, and create a corner in the supply of a commodity indispensable to the maintenance of our manifold industries, the British Science Guild have thought the time opportune to publish a report on natural sources of energy, which they have had in preparation for some time. Unfortunately, the report is by no means complete, since the sections dealing with wave-power, wind-power, and power derived from the sun, and from certain other sources, are not ready, yet, as it stands, the various papers contain much interesting matter and an editorial comment on this subject recently published in *Engineering*, is well worth quoting at length.

The quantity of energy which, using the word in its strictly scientific sense, is "available" for the production of motive power is, of course, practically unlimited. Each atom appears to have locked up in it stores of energy vastly out of all proportion to those now exploited. But though highly "available" in the scientific sense, these stores are for the present absolutely inaccessible, and it seems extremely doubtful whether a key capable of unlocking them will ever be forged by mankind. So far as this source of energy is concerned, we are therefore thrown back on to the recognized radioactive elements, of which the best known are radium, thorium, and uranium. In the report dealing with this section of the subject Sir William Ramsay estimates the energy liberated in the break-up of one ton of radium as 460,000 times as great as is developed in burning a ton of coal. Even were it commercially practicable to utilize the energy of radium for power production, however, we should be little further forward, since Sir William Ramsay is of the opinion that the total amount now existing in the uranium ores of the entire globe does not exceed 5 hundredweight, which could at most replace some 125,000 tons of coal; and the unfortunate fact remains that this liberation of energy would have to be spread over a period of some 350 years, since there seems no prospect of any method being found by which the disintegration of the radium atom may be hastened. If such methods were found, moreover, they would probably be exceedingly dangerous to the experimenter. The late Prof. Curie once remarked that he would not care to venture into a room containing a pound of radium, and the application of the extraordinary intense forces which would certainly be required to hasten atomic disintegration could hardly fail to be extremely perilous if applied on a scale possessing any industrial importance whatever.

Another copious supply of energy is to be found in the internal heat of the earth. When President of the Engineering Section of the British Association in 1904, Sir Charles A. Parsons discussed the feasibility of constructing a bore-hole 12 miles deep, and came to the conclusion that it would be practicable. At that depth the normal temperature of the rocks would, he estimated, be 272 degrees Fahr., and it might, perhaps, be possible to utilize this increase of temperature for the production of motive power; but at best the amount would hardly be commensurate with the cost of the undertaking, which, allowing for the payment of interest during construction, would amount to many millions sterling. The general question of developing power from the internal heat of the earth is discussed in the report under review by Prof. Strutt, who comes to the conclusion that, though this might be possible in favorable local conditions, it could only be effected on a relatively small scale, and that there is no reason for believing that the ultimate exhaustion of our coal supplies could be made good by energy thus derived, vast as is its total amount.

The possibilities of oil as an alternative to coal are considered by Prof. Boverton Redwood, who estimates that the total present production of crude oil would only suffice to provide about one-sixth of the power now developed by coal, and it has further to be remarked that the problem of applying the internal-combustion engine to really large developments of power is still unsolved. The announcement has been made that Messrs. C. A. Parsons & Co. have just commenced to construct a steam-turbine to develop 25,000 kilowatts, and there is no reason to believe that the limit of size has yet been attained. As matters stand, the construction of an internal-combustion engine on any equivalent scale is commercially quite impracticable.

In England about one-fifth of the total coal supply is now used for domestic purposes, according to an estimate made by Dr. Beilby. This coal is probably used with less economy than in any other application of the fuel, and contributes a very large proportion of the total contamination of the atmosphere by smoke. Of the remainder, about 70 per cent is utilized in power production, and here, no doubt, notable economies would be possible did the gas-engine provide as convenient a method of developing power as is afforded by steam. Mr. Dugald Clerk gives 30 per cent of the heat of the fuel turned into useful work on the shaft as about the best result now attained with the internal-combustion engine. Since in general the gas has to be obtained from a producer, the efficiency, as referred to a coal basis, is considerably lower, so that the consumption of coal per shaft horse-power is not very much, if any, less than has recently been realized with steam turbines. Sir C. A. Parsons states that with a steam-turbine of 10,000 kilowatts capacity a consumption of very little over 1 pound of coal per shaft horse-power has been realized. We may add that experiments yet unpublished have shown that a result equal to this can be obtained with reaction turbines of only 1,000 kilowatts capacity, a consumption of 8.1 pounds of steam per brake horse-power hour having been recently recorded in independent tests carried out by engineers of undoubted competence. In the matter of fuel economy, therefore, this turbine must run the engine using producer-gas pretty closely. Probably both motors are susceptible of further improvements; and, in fact, in the report under discussion, Mr. Dugald Clerk states that in large gas-engines it is possible that an efficiency of 40 per cent on the brake may yet be realized. Of course, where the gas is a by-product from a coke-oven or blast-furnace, the gas-engine has a considerable advantage in the matter of fuel economy even over steam turbines of the largest size, and for small plants it maintains this advantage even when required to operate with producer-gas. A 60-horse-power gas engine is as economical as one of 1,000 horse-power, but this is very far from being the case with steam.

The question of water-power development in the British Isles is dealt with in the report by Mr. W. F. Reid, who states that there are very considerable areas having an average rainfall of 60 inches per annum, and situated at a level of over 1,000 feet above the sea. Could the whole of this rain be caught, and the full fall utilized, the energy developed per acre would only suffice to maintain 10 horse-power for about 700 hours. So that an enormous gathering ground is needed to develop any very great amount of power.

It is interesting to compare this limited power derivable per acre with that which, theoretically at least, could be obtained from the sunlight falling on an equal

area. An estimate given by Sir J. J. Thomson, in his lectures at the Royal Institution last year, is that, shining from a clear sky, the sun sends to the earth energy at the rate of 7,000 horse-power per acre. It has, moreover, to be remembered that as the temperature of the sun is some 6,000 deg. Cent., this energy must arrive in what, in the scientific sense of the term, is a highly available condition; that is to say, that, theoretically, it ought to be almost wholly convertible into mechanical work. Such attempts as have hitherto been made to derive power from this source have, however, involved the destruction of this availability, since the energy in question is converted into low-temperature heat, of which only a small fraction is recoverable as mechanical work. Should our physicists succeed in devising some direct method of converting this energy into work, steady depletion of our coal reserves may be viewed with unconcern, since even in temperate climates the supply of energy will be ample to maintain civilization at the level to which the labors of the engineer have raised it.

# American Aeronautic Motors

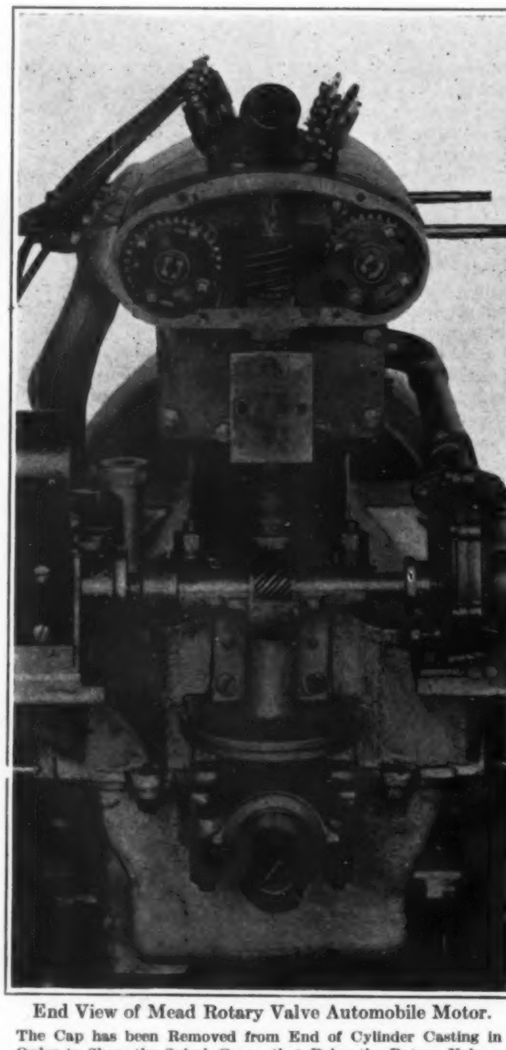
## Description of Some of the New Aviation Engines Manufactured in the United States

### By Stanley Yale Beach

First-class aeronautic motors are now being produced in America. A year ago it was a difficult matter to find a reliable aviation engine of domestic make that could be purchased even at an exorbitant figure. Now this has been changed and good motors of several successful types can be had at a reasonable price.

In the present article we describe three different types of American aviation motors that have flown aeroplanes successfully. Since the success of the Knight sleeve-valve automobile motor abroad, a great impetus has been given to the invention of motors with new types of valves, and many such novel motors have been produced. One of the most interesting of these constructed in America is the Mead rotary-valve motor, which is the invention of Mr. Cyrus E. Mead, of Dayton, O. The invention of this motor dates back five years, and during the past two years several models have been built in different sizes and many interesting experiments have been made. These engines have been mostly of the 4-cylinder vertical type so largely used in automobiles. An end view of one of them, showing the spiral gears that drive the rotary valves, is given in the annexed illustration. The spiral gear at the upper end of the vertical shaft (which is driven from the crankshaft) meshes with two spiral gears on the ends of the rotary valves, causing these to be driven at one-quarter the speed of the crankshaft. Each valve consists of a straight bar of cast iron with suitable slots cut in it. When the valve is in the proper position each slot makes a straight through passage from the carbureter to a cylinder (inlet side), or from the cylinder to the outer air (exhaust side), as shown in one photograph of the aeroplane motor, where the exhaust of the right-hand cylinder is shown open. The T-head cylinders used, in combination with the rotary valves, make the entrance and exit of the gases by so straight a path that there is no wire-drawing. As a consequence the horse-power and torque rise rapidly in practically a straight line with the revolutions per minute of the motor up to 1,700 or more, instead of falling off after a speed of 1,500 has been reached, as is the case with most poppet valve motors.

The diagrams show this falling off in horse-power of a poppet valve motor as compared with the continuous development of increased power at the higher speeds with the Mead rotary valve engine. The torque curve shows that a maximum is reached at 1,550 revolutions per minute, beyond which the torque decreases.

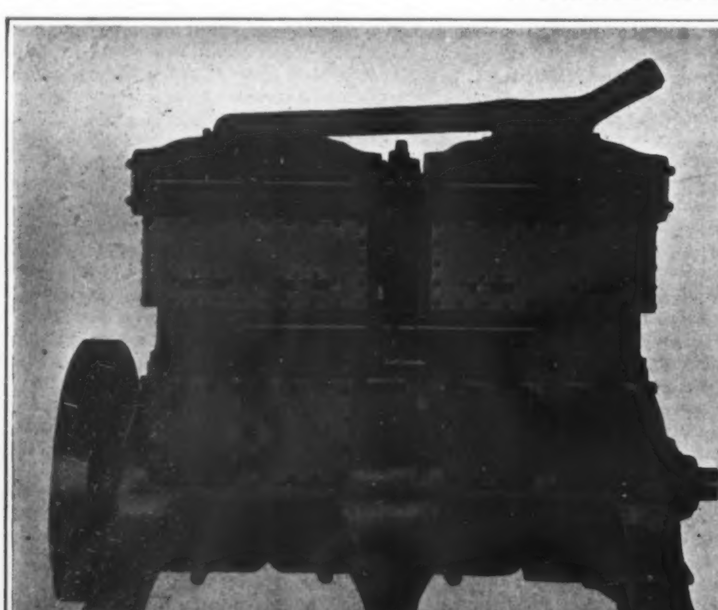


**End View of Mead Rotary Valve Automobile Motor.**
The Cap has been Removed from End of Cylinder Casting in Order to Show the Spiral Gears that Drive the Rotary Valves. The Magneto and Water Pump are at the Ends of Cross Shaft.

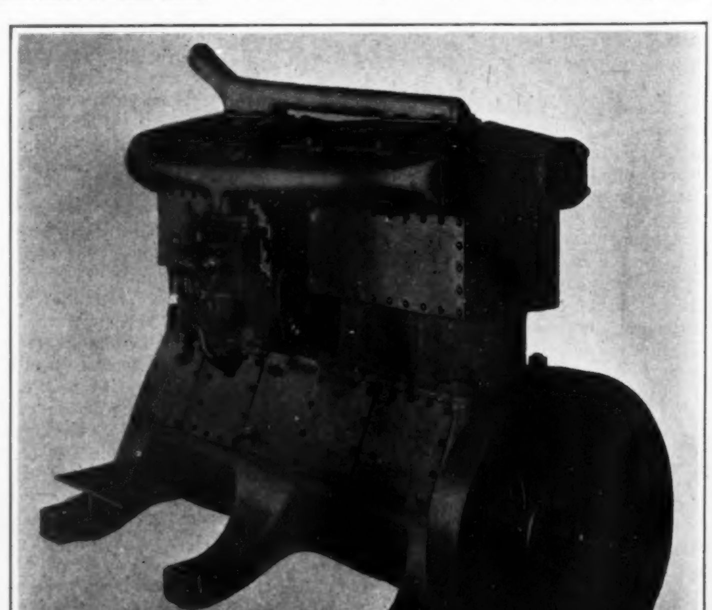
The excellent qualities of this motor make it especially adaptable to aviation, and the company has recently brought out a four-cylinder, vertical, water-cooled motor for the Wright biplane. This motor was exhibited at the Aero Show, and it is illustrated herewith. In order to lighten the motor as much as possible, a chain drive for the valves was resorted to. This works satisfactorily, as there is a constant rotary motion with no back lash, which is the case when cam-driven valves are used. The power required to operate the rotary valves is very slight in comparison with that required to drive the usual poppet valves. The rotary valves and their seats are both of cast iron. The valves are 1¾ to 2 inches or more in diameter, and there is 0.001 inch clearance between valve and casing. At no time is there a pressure of the valves against their casing of more than 20 to 30 pounds to the square inch, and, as they are well lubricated by the introduction of oil mechanically into the inlet pipe manifold, there is practically no wear even after a long period of use. A cam controlled lubricator has been invented that supplies oil to the valves in proportion to the power developed and to the fuel consumed. The aeronautical motor shown has been run 7½ hours continuously at 1,100 revolutions per minute when under test, while an automobile type motor has been run 76 hours under full load without appreciable wear of the valves.

The aeroplane motor has a bore and stroke of 4½ by 4¾ inches, weighs complete 275 pounds, and develops 50 horse-power at a piston speed of 1,000 feet per minute. While it is a heavy aviation motor, this is offset by the fact that it can be depended upon to run continuously for long periods at a stretch.

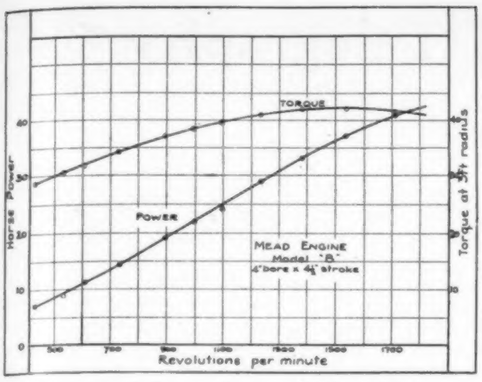
The six-cylinder motor which we illustrate is the latest product of the Sturtevant Manufacturing Co. of Boston. In designing this motor the best type of automobile engine has been closely followed, the idea being to make an engine that will run continuously with a full load for 12 hours or more at a stretch without oiling or adjustment. Durability and reliability are considered of more importance than weight by the makers, and as a consequence the motor has not been lightened to extremes. Nevertheless, it weighs but 285 pounds complete with magneto, carbureter, and oil tank, and develops 60 horse-power at 1,200 revolutions per minute. The engine is made up of six individual cylinders having a bore and stroke of 4½ inches.



**Exhaust Side of Mead 50 Horse-power Motor, Showing Chain-driven Exhaust**
Note Auxiliary Exhaust Ports Cut Through Lower Part of Water Jackets



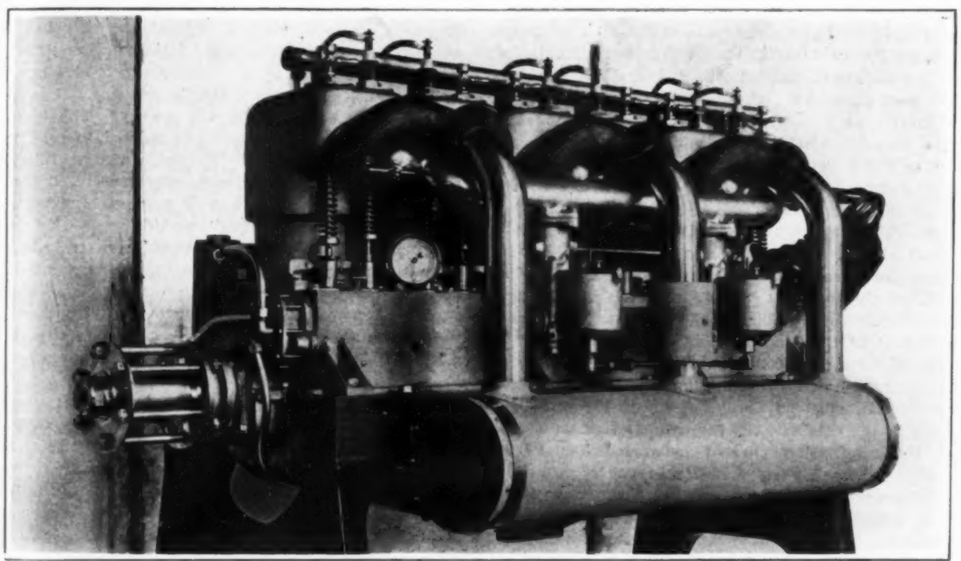
**Inlet Side of Mead Rotary-valve Motor for Wright Biplane**
Note Valve Driven by Sprockets and Chain.




Torque and Power Curves of Mead Motor.

These cylinders are of the L-type with the valves side by side in a valve chamber. They are connected to a common inlet pipe on which are placed two carbureters, as shown in the illustration, while the exhaust pipes are connected in pairs and run into a muffler. The oil pump is connected directly to the end of the cam shaft and made to draw oil from the tank at the side of the motor and to force it through a series of passages cast in the crank case into the hollow crankshaft by way of the main bearings. Small holes in the crankshaft allow the oil to pass up through the connecting rods to the wrist pins. The spray produced in the crank case covers all moving parts and collects in the sump at the bottom of the case. A second gear pump, connected in tandem with the pressure pump, draws the oil from the sump and forces it through a filter into the oil tank, where it is cooled before being used again. This oiling system makes it possible to use a better filter than can be used if it is of the suction type. Should the filter become clogged and tend to stop the oil supply, the pump is capable of producing sufficient pressure to burst the same. The filter can be readily removed for cleaning whenever this is found necessary. As no oil collects in the base of the motor, the latter can be tilted at an angle without affecting its operation. A tank is provided with every motor sufficient for a 3-hour run. A large centrifugal water pump is mounted on the end of the crankshaft, thus doing away with a special bearing and connection. The Mead magneto is gear driven from the crankshaft.

The propeller end of the crankshaft is shown in our illustration. A suitable flange is fitted to it with a taper for the attaching of the propeller, and there is a thrust bearing between the flange and the end bearing of the crankshaft. The oil pump, with its connections to the oil tank and the crank case, is shown plainly in our illustration, as is also the carbureters, inlet and exhaust pipes, and muffler. The fitting of a muffler to an aeronautic motor is somewhat of a novelty, but it is a very desirable feature. The extra weight is not appreciable, and the result in the production of a quiet flying machine is excellent. The crankshaft of the Sturtevant motor runs in plain bearings, there being a bearing between each throw. The shaft is made from a solid block of high grade nickel steel having an ultimate tensile strength of 125,000 pounds per square inch. The shaft is of large diameter and bored hollow from end to end. The cam shaft is also made from a single piece of steel, with its cams cut on it at the proper locations. The bearings in the crank case, which are of an especial aluminium alloy, are fitted with interchangeable die-cast bushings of Parsons' white brass. These bushings can be readily removed if necessary. The lower half of the crank case is a light aluminium casting, as it is only intended for holding the oil. The cylinders used are of a special semi-steel mixture from a crucible, and they have a tensile strength of 40,000 pounds per square inch. The water jackets are cast integral, and consequently there can be no danger of leakage at the joints, as is the case with applied jackets. The cylinders are tested with an hydraulic pressure of 600 pounds to the square inch before being heat-treated and accurately ground. The arrangement of the valves on one side makes possible their operation from a single cam shaft without the use of rocker arms or long push rods. Consequently there is no oiling by hand or adjustments required.



Valve Side of Sturtevant 6-cylinder 60 Horse-power Motor, with Propeller End of Crankshaft in foreground.

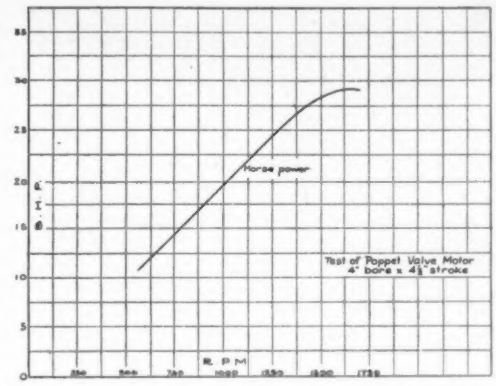
The Duplex Gear Pump for Circulating the Oil is Seen at the Left-hand End Connected to Bottom of Crank Case and to Oil Tank. The Magneto Appears at the Other End of Motor. Note Two Zenith Carbureters and the Exhausts Connected to Muffler. The Last Increases the Weight of the Motor Eighteen Pounds.

All the motors produced by the Sturtevant Company are tested in actual use with a propeller for several hours, and they are afterward given a final test when connected with a dynamometer. The horse-power ratings—40 for the 4-cylinder and 60 for the 6—are conservative in view of the fact that the former motor has shown 52 horse-power and 375 pounds thrust with a 4½-foot pitch propeller when running at 1,200 revolutions per minute, while the latter has developed 60 horse-power. This motor is one of several 6-cylinder engines that are being made by different manufacturers at the present time.

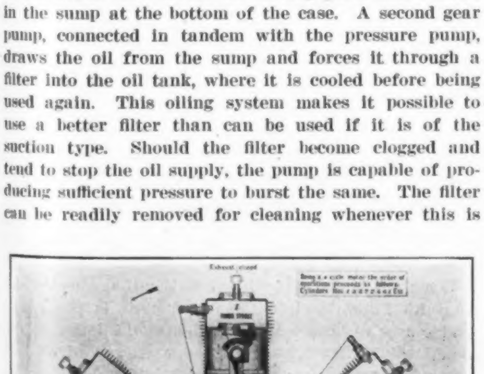
Two other illustrations show the general appearance and cross section of the "Gyro" revolving-cylinder motor. This motor has been produced by Mr. Emile Berliner at his laboratory in Washington, D. C., after a long period of experimentation and a study of the Adams-Farwell and the Gnome motors. Mr. Berliner has improved upon the Gnome motor in several ways, the chief improvement being the use of a mechanically-operated inlet valve located in the head of each piston. There are but two operating parts to this valve, one being a counter-balancing member (seen above) and the other a club-shaped piece pivoted to a lug on the end of the connecting rod. Centrifugal force is used to open the valve, while the closing is effected by the movement of the connecting rod causing the club-shaped arm to act on the small lever above it and draw the valve down to its seat. This mechanically-operated valve is a great improvement over the automatic inlet valves used in the Gnome motor. Another improvement in the "Gyro" motor consists in doing away with any rings whatever on the piston. The outer shell of each piston is of fine converted iron of special elastic formation, the result being that it conforms perfectly with any size or shape occurring in the cylinder. Castor oil is used to lubricate the motor and keep a tight joint between the piston and cylinder. The top of the piston is made up chiefly of the inlet valve support. This is machined from a steel bar and carries the wrist pin, inlet valve, and operating mechanism. An oil deflector is placed at the bottom of the piston. This closes the bottom of the piston except for a hole through which the connecting rod passes. The cylinders of this motor, which are of a high grade steel, are provided with exhaust valves in their heads and with exhaust ports near their lower ends. These ports are bored diagonally through a re-inforcing ring formed upon the cylinder at this point. The inclined position of the ports makes it impossible for oil to escape through them, as it is held in by centrifugal force. The exhaust valves are operated by levers and push rods worked from a cam arranged in the crank case. A single cam ring works the entire set of valves. The oil and gasoline are both fed by means of a pump which supplies the proper quantity of each. Both are fed through the stationary hollow crankshaft. They mix in the crank case as with the Gnome motor, but instead of a large percentage of the oil passing through the inlet valve in the head of the piston and escaping through the exhaust valve and auxiliary ports, the deflector on the bottom of the piston distributes the oil thoroughly over the cylinder walls.

Another feature of the "Gyro" motor is the compression release. The exhaust valves can be held open throughout all or any part of the compression stroke. As a result the motor can be turned over readily with the compression released, until the cylinders are charged, after which it can be readily started.

The "Gyro" motors are made in three sizes of 22, 35, and 50 horse-power, respectively, and having three, five, and seven cylinders, with a 4.30-inch bore and a 4.75-inch stroke. On account of the special materials and workmanship the weight complete of these motors is but 3½ pounds to the horse-power. The 50 horse-power motor turns an 8-foot diameter, 5.2-foot pitch propeller 1,200 revolutions per minute, and gives a stationary thrust of 440 pounds. The record in flight of one of these motors is 2 hours and 18 minutes.

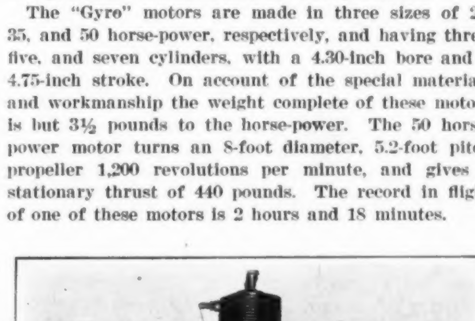



Horse-power Curve of Ordinary Poppet Valve Motor.



Section Through Gyro Motor.

Note the Master Connecting Rod with Other Rods Pivoted About Its Big End. Also the Valve-operating Parts at the Outer Ends of all the Connecting Rods.



Rear View of 50 Horse-power Gyro Motor.

Note the Spark Plugs and Exhaust Valves at Outer Ends Cylinders; Also the Auxiliary Exhaust Holes in Beveled Flanges Near their Bottoms.

# The Present Position of Wireless Telegraphy*

## A General Survey of the Situation

By Count George von Arco†

The most important technical progress made by wireless telegraphy in its fourteen years' development is due to the laboratory work of the large firms engaged.

The two undertakings which control its development almost exclusively are the Marconi Company in England and the Gesellschaft für drahtlose Telegraphie in Germany. The former took the lead during the first ten years of development, while the latter has come to the fore in the last few years.‡

Prof. Slaby was stimulated to new ideas of his own after witnessing the first Marconi trials in the year 1897. He designed an independent wireless system which was worked out in the Oberschöneweide cable works of the Allgemeine Elektricitäts Gesellschaft. Almost simultaneously Prof. Braun, of Strassburg, secured a number of fundamental German patents, the use of which he transferred to the firm of Siemens & Halske. In the year 1903 the two large firms founded the Gesellschaft für drahtlose Telegraphie m. b. H. for the common exploitation of these patents. The name "Telefunken" was selected for the system. The operations of the new company were at first restricted to the delivery and installation of wireless stations principally for military purposes.

Marconi's inventions were exploited by an English company which undertook both the delivery and installation of plants, as well as the erection of wireless stations for the transmission of general news. The favorable geographical and political position of England was very advantageous for this purpose. The organization of the English company for the transmission of news was already very extensive and well established, and an English Marconi world monopoly for the wireless transmission of news was half completed when the German company decided to extend its activity to this branch also.

After the Telefunken company had installed stations on some of the ships of the German mercantile fleet, the Marconi company refused a mutual communication on being called up by German ships. On this account the German merchant service was compelled to equip all its ships with Marconi stations, and to include the telegraphists of this foreign organization in their crews. In view of the great interest which the German state authorities and shipping circles had in putting an end to these conditions, the Allgemeine and Siemens & Halske concerns determined to come to an agreement with the Marconi company at a considerable financial sacrifice to themselves, by which the wireless service on board German mercantile ships was taken over by a newly formed company, "Deutsche Betriebsgesellschaft für drahtlose Telegraphie m. b. H." This company has the right of employing the German Telefunken and Marconi patents, and the 160 ship stations which it operates at the present day enjoy the same rights as the remaining Marconi stations. Thus at the present time the German company, including both the supply and operating companies, takes part in the working of the wireless system.

The number of stations installed is a guide to the importance of the different firms in the markets of the world. The office at Berne, in its official list for the year 1910, mentions some 1,300 wireless stations which are distributed throughout all parts of the world. Of these, 80 to 85 per cent are registered as employing the Marconi and Telefunken systems, the use of the two systems being about equally divided.

The principal apparatus in every wireless installation is (1) the transmitting apparatus for producing high frequency alternating currents, (2) an antenna for radiating this energy, (3) a second antenna at a distant point for collecting the incoming radiations, and (4) a receiver which makes them perceptible.

The alternating currents may take two different forms: (1) undamped or (2) damped wave-trains. The first are produced either in accordance with Poulsen's method by an arc in an atmosphere of hydrogen, or directly by means of an alternating-current dynamo specially built for this purpose, a so-called high-frequency machine, and the latter are produced by a spark discharge. The arc method has not fulfilled the hopes placed in it and its application in practice has remained very limited.

The continuous oscillations have only one single periodicity, the number of oscillations per second; the intermittent oscillations, on the other hand, have, in addition to the number of oscillations, a periodicity of the groups. As each group is derived from the energy of one spark discharge, the periodicity of the groups is equal to the rate of sparking per second. A transmitter with intermittent oscillations can, therefore, possess more individuality.

As already mentioned, frequencies up to 1,000,000 periods per second are adopted for high-frequency currents in our technique. Such frequencies cannot be produced either at the present time or at any early period in the future by a high-frequency dynamo. Alternating currents of 50,000 periods have, however, also acquired a certain value in the last few years, particularly for telegraphing over very great distances. Such frequencies can be generated directly on the dynamo principle from mechanical energy, by means of special dynamos.

The high-frequency machine is expected to produce an increased wave energy. Hitherto, however, no failure in wireless telegraphy has been due to the fact that insufficient quantities of energy were available for the transmitter, but because they could not be radiated. The antenna difficulties limit the outputs. When antennæ have actually been invented by means of which 500 or 1,000 kilowatts can be radiated, then perhaps the spark method will fail, and then the machine may assume a greater importance.

High-frequency currents up to more than 100 kilowatts, and frequencies up to millions per second, and down to a few thousands, are produced with spark discharges. The most modern spark method can be well demonstrated by means of a tuning fork which is struck. The energy is imparted to the tuning fork by a short stroke, and this energy is converted into an acoustic wave train of decreasing amplitude, and radiated. When the tone has entirely or nearly died away a new stroke is given. The hammer strokes correspond to the sparks in the electrical simile. The quantity of energy of a spark is converted into an alternating-current wave train of decreasing amplitude.

In German stations the sequence of the strokes is usually at the rate of 1,000 per second. Let us assume that the alternating current generated has 100,000 periods, and that each wave train ceases after 100 oscillations, then the intervals between the wave trains exactly disappear and the new spark always occurs at the moment when the previous wave train ceases. The spark method has some advantages over the machine. Of these we only mention the absolute constancy of the periodicity which is here dependent upon fixed electrical values, the double characteristic of the transmitter for high and tone frequency, and the variable accumulation of the energy per second for obtaining greater momentary effects at the receiver.

The most perfect form of the spark method at the present day is the "sounding blow-out spark" system. Three electrical properties should be mentioned in particular: (1) the intervals between the wave trains are extremely short, (2) the distances between the groups are of equal length and the wave trains follow one another with absolute regularity, whereby a tone is produced in the receiver telephone; (3) the rapidly extinguished spark has the further advantage that it exists only during the very first oscillations, a long aerial wave train continuing after its extinction. The energy loss of the spark is confined to a very small fraction of time, or speaking practically, it is entirely overcome. After a long period of laboratory work, this extinguishing principle, given by Prof. Max Wien, has been developed by the Telefunken company to a stage of perfect reliability, even in plants working with a wave energy of 100 kilowatts.

The available high-frequency energy is led to the antenna by the transmitter, a part being radiated from it and producing a distant effect. This is the actual work of the antenna. Only very recently has more light been thrown upon the phenomena occurring in the antenna, and the distance effects. Within the last two years Dr. Kiebitz, engineer in the telegraph experimental department, has carried out new experiments with improved earth devices, and has published the results, some of which are very favorable. Among other matters, he states that by means of an antenna erected by five workmen in one morning he was able to hear the signals of a station in Canada at 3,700 miles.

The form of antenna hitherto employed generally consisted of wires with an upper conducting end surface, which were led vertically upward and supported by high masts; the dimensions were dependent upon the distances and the quantities of energy. The greater the distance to be bridged over, the greater must the energy be which is sent into the antenna and radiated from it. The greater the energy is, the larger must the antenna be, both as regards the upper wire surface and the height of the same. The cost of the towers increases almost as the cube of their height. Here, then, lies the practical limit for the transmission range of wireless transmitting stations. It is certainly possible to generate 100 or even more kilowatts in the form of high-frequency alternating current; one cannot, however, build without enormous expense an antenna which will radiate it satisfactorily. If the earth antennæ fulfill all the hopes which many experts promise for them, then perhaps a new epoch in the construction of large wireless stations will begin for the longest distances ever known to our world, and then perhaps the high-frequency generator will receive preference over the spark system. One must not be too optimistic, however.

The same antennæ are used for receiving as for transmitting. By syntonizing the receivers greater distances can be covered on the one hand, and on the other hand it is possible to receive the signals of other transmitters, or not to hear them, according to the adjustment. How are the weak currents of the receiver antenna made perceptible? The telephone cannot be operated by them, as its diaphragm is much too slow to follow the 100,000 or more periods of the receiving current. The acoustic organ of the human ear is also too slow and would not hear these telephone tones. It is therefore necessary to convert the energy. The high-frequency alternating current is converted to continuous current. This is effected by means of a rectifier, the detector, which at the present day usually consists of a metal point in contact with a special mineral, for example, platinum and lead sulphide.

From a damped high-frequency wave train a continuous current impulse is produced by rectification, and the latter finally moves the membrane of the receiver. A movement of the membrane takes place for every distant spark. At 1,000 sparks per second the tone with 1,000 vibration periods at the receiver is heard.

The technical progress of the last few years can best be realized from the extended range of application. The transmission distances of the stations have been relatively increased, as it is now possible to transform 50 to 75 per cent of the machine energy into antenna energy. Requirements can, therefore, be met with smaller primary plants. Owing to the omission of intervals between the wave trains, more energy can be led to one and the same antenna, and owing to the short duration of the spark, it is possible to transform very large quantities of energy into vibrations without disturbing the spark electrodes. The freedom from disturbances caused by other stations and atmospheric discharges has also been extraordinarily increased.

The construction of all apparatus differs fundamentally according to whether it is required for military purposes or for the transmission of general news. In case of war it is necessary to get one's telegrams through, notwithstanding intentional disturbances caused by the enemy. A large selection and a large tone scale is required, and it must be possible to make all alterations in the electrical adjustment as quickly as possible. Complications and high prices for the apparatus are the natural result.

The apparatus for the mercantile fleet is much simpler and smaller, since as a rule only short distances come into question.

When one hears that with these small stations, which send 1.5 kilowatts into the antenna, it is possible to bridge over distances of many thousand kilometers, one would think that with an antenna energy of 35 kilowatts it would be possible to reach fantastic figures. This is not the case, however. These long-distance results on ships are obtained at night. During the day, only 600 to 700 kilometers can be covered.

Marconi was the first to recognize the cause. Light is the enemy of electric waves, and a greater enemy and energy disturber, the higher the frequency of the alternating current. It is certainly easy to produce low frequencies but very difficult to radiate them economically. The antenna determines the maximum frequency, by its height. The higher an antenna is, the better it is for low frequency. Thus we are here faced by a great difficulty. If it is desired to make a permanent connection over a long distance, a connection which will work in the strongest sunlight, as for example, at midday in the tropics, then a low frequency is necessary. For this purpose a very high antenna is required. Marconi was also the first to establish a permanent connection over 1,900 miles between England and Canada, which is still the only plant of the kind. His two stations are the same size, and have enormous antennæ.

* From a paper published in the Allgemeine Elektricitäts Gesellschaft *Journal*, and appearing in English in *Engineering News*.

† Deutsche Betriebsgesellschaft für drahtlose Telegraphie, Berlin, Germany.

‡ It is now announced that the United Wireless Company, controlling the American commercial service, has been consolidated with the Marconi Company.

# Effect Upon the Ears of Rapid Transit Through Tunnels

## A Familiar Sensation Discussed

### By Edmund Prince Flower, M.D.

It is a common experience for passengers traveling through the submarine tunnels connecting Manhattan Island with New Jersey, and with Long Island, to notice a sensation of blocking of the ears during this part of their journey. Those who have felt the sensation naturally wonder if others are affected likewise, and usually have their curiosity satisfied a moment after the phenomenon occurs by seeing many passengers take hold of their respective noses with thumb and forefinger, forcibly expire into the nose, and thus relieve the disagreeable sensations.

It is apparent that the ears have become blocked by a change in air pressure, but the amount of pressure change, the mechanism by which it is occasioned, and the effect upon the ear, have not been heretofore investigated.

To determine the air pressures, I employed two very accurate and sensitive aneroid barometers, one in the hands of an observer in the forward, and one in the rear car of the train. On several occasions readings were also taken in the interior cars. Eight trips were made, and the barometric pressures noted especially as follows: Before the train started; while moving on the surface, rapidly, and slowly; on entering tunnel; descending; near middle of tunnel; ascending; emerging from tunnel; especially all extreme excursions of the indicator hand at any point of the journey.

The pressure changes varied greatly on different trips, owing mainly to the speed at which the train was traveling. The greater the speed, the greater and the more sudden the barometric fluctuations, and naturally also the effect upon the ears. Briefly, on entering the tube, the air pressure rose quickly, about 1/5-inch of mercury, in the forward car. In the middle cars less, and in the rear cars usually a still smaller amount, the pressure even being lowered in the latter situation on several occasions. The pressure varied at several points, owing to changes in level, the rate of progress, and the proximity of ventilating shafts. The opening or closing of windows had a marked effect on the air-pressure changes. In the forward car I observed at no time a greater variation than 3/10-inch mercury.

In the rear car more marked changes were noticed and on two occasions there was a fall of over 4/10-inch mercury within the space of about one second. This occurred on passing one of the exhaust shafts, and was due to the partial vacuum brought about by the combined action of the exhaust shaft and the rapidly moving train. The extreme range of pressures during a trip was equivalent to ½-inch mercury. This did not occur suddenly, there being many forward and backward excursions of the dial hand before it was accomplished.

I have given the data as variations, instead of actual readings of the manometer, as the latter would be confusing owing to the differing surface air pressures on the various days, and as it is with the changes, and not the height of the barometric readings with which we are concerned. Some allowance must be made for pressure changes due to the varying grade of the tracks, but this is of but small importance, as the grading is never abrupt, and the rails are more on a level than is generally appreciated.

A change of pressure of ½-inch mercury would, on first thought, appear to be but a trifling variation, but when one considers that it represents a pressure of about ¼-pound to the square inch it is apparent that no inconsiderable factor has to be dealt with.

Such a pressure brought to bear upon the drum membrane of the ear is surely more than enough to occasion symptoms of its presence, when, as I have shown some years ago, a fraction of a millimeter of change in pressure is easily detected by the ears, not only as a sensation of pressure, but as a distinct inhibition of the acuteness of hearing. This occurs if the pressure is applied upon the external surface of the drum, and within a comparatively short space of time, as otherwise the air pressure in the middle ear will also increase by the way of the Eustachian tube, and the differing pressures on the two sides of the drum membrane will be equalized.

If the walls of the Eustachian tube are abnormally adherent to each other, or if the lumen is stenosed so that the physiological ventilation of the middle ear is prevented, any change in air pressures will be more definitely recognized than it would be otherwise, and the effect on the hearing will be greater. Pathological processes in the middle ear may inhibit or enhance the effect of changing air pressures, depending upon whether they interfere with or aid such pressures in reaching the membranes in the external labyrinthine wall.

The principal factor in producing the phenomena under consideration is the suddenness with which the changes occur. If the change is a lowered pressure the effect upon the ear is more marked than would be an equivalent increased pressure, and for the following reasons: Diminished pressures tend to suck the walls of the Eustachian tube together, whereas increased pressures tend to force them apart. The latter, therefore, tend to facilitate the equalization of pressures upon both sides of the drum membrane, and the former to hinder such equalizations. The greater the suction the closer are the tubal walls drawn together, and the more certain is the communication with the nasopharynx shut off.

As to any detrimental effect upon the auditory apparatus; it is apparent that subjection every day or twice a day to the extreme air pressure changes noted on some of my trips would be injurious, and especially to those suffering from certain tubal and catarrhal troubles. Unless the ear blockage is relieved within a few moments after it occurs, retraction of the drum membrane, and blocking of the tube is accentuated. Especially is this the case if the ears are exposed first to an increase, and then immediately to a sudden diminution in air pressure. (This frequently occurs in tunnel travel.)

To the normal ear no harm should result from air pressure changes greater even than those experienced in the tunnels, for the voluntarily, or involuntarily excited act of deglutition, quickly relieves the ear block in such cases. Persons in whom the ordinary act of swallowing does not at once relieve the blocking, should consult an otologist, as they have received a significant warning that all is not right with their auditory apparatus.

In many cases instant relief and protection from future trouble may be obtained by simple means. The common practice of forcibly blowing into the nose (Valsalva's experiment) may work great harm, as it is wholly unphysiological and dangerous.

In suitable cases the author's method of middle ear inflation is all that may be required, and I recommend it for this purpose, not only because of its efficiency, but because it is always at hand. It is executed as follows: While the nostrils are tightly closed by pinching them together with the thumb and forefinger as near their free borders as is possible, gently increase the air pressure in the nose and nasopharynx by attempting to expire wholly through the nose, and, while maintaining this increased pressure, swallow. The result will be the inflation of both middle ears. This is brought about by the opening of the tubes during the increased nasopharyngeal air pressure, due to the patient's efforts and to the ascent of the soft palate. During the second stage of deglutition a negative pressure is avoided, because the primary increase in pressure and the bulging of the elastic lateral walls of the nose supply a sufficient amount of air reserve to enable the descent of the soft palate to occur without creating a partial vacuum in the nasopharynx. Until familiar with this method of inflation it is well to take a full breath preliminary to its performance. No instruments are required for its performance, and anyone with ordinary muscular control can easily learn to inflate the ear safely by this method.

* Reproduced from the *Medical Record.*

# Oil Losses by Fire

## Some of the Causes and Methods of Fighting the Flames

### By Charles A. Sidman

It has been estimated by the Geological Survey of the Department of the Interior that there is lost annually more than a million and a half barrels of oil by the burning of oil wells, and from other causes.

The greatest loss is during the months of May to October, and is occasioned by any number of causes. The principal one seems to be the careless use of matches. Other reasons which cause fires in oil wells are from lightning, from the spark of an automobile, and from the gases which emanate from the wells.

It sometimes happens also that a well is flowing at such a great rate that the bearing of the pump may develop a serious leak, and spray a great many barrels of oil on the ground before it can be stopped. If a thunder storm should arise at that time, there is danger of the well's catching fire from lightning, and causing a great deal of damage as well as loss of life.

A case of the kind just mentioned, happened in the State of Louisiana, with a very large well which had a flow of oil variously estimated at from 8,000 to 25,000 barrels a day. A leak developed which could not be stopped at once, and while waiting for suitable machinery to arrive, a severe thunder storm broke out. The well had been spraying oil from the leak for several days, drenching the men working near it, which made it especially dangerous for them, for it happened that the oil was of such a gravity that it contained about twenty per cent of gasoline and was very inflammable.

The men who were working on the well are termed "greasy men," and when this storm came up were ordered to a nearby stream of water, so that if lightning did strike the well they could plunge in and thereby save themselves.

The well was struck, and there immediately began a fight to extinguish the fire. The gases in the well threw the oil to a great height, causing danger to life and property as well.

The simplest method to extinguish the fire seemed to be to drown it out by means of steam. Twenty-five steam boilers were secured from a nearby city, brought to the well, and attachments made with a nearby natural gas well, and the fire was extinguished within forty-eight hours. For several hours afterward the ground was sprayed with hot steam to be sure that no fire remained.

There are several ways of effectively stopping a fire in an oil well. It can be stopped by water to a certain extent, but the danger of the oil's spreading, and of the vapor thrown off by the evaporation of the water does not make it safe to try this method with a large fire. In cases of small fires it might answer, but not always. Steam driven by force pumps is an effectual means of killing a fire, and is resorted to in most cases. In many of the oil fields one will see many buckets of sand lying around the wells. Aside from being a cheap method of fighting fire, it is also one which can be performed with ease, for a man can pick up a bucket and stop an incipient fire almost as soon as it has started.

Many of the large and modern oil companies have had installed in their fields and near their refineries a system of high-pressure water pipes for use in such cases of sudden fires. High-pressure steam pipes are also run into the fields for the same purpose. It is interesting to note in the case of a field of tanks, the means taken to prevent fires. The majority of the tanks have a sort of sprinkler system installed. A large iron pipe is placed around the top of the tank. This is punched full of holes, and at the outbreak of a fire the high pressure is turned on, which causes a flow of water to run down the outside of the tank. At the same time hot steam is introduced inside of the tanks by the same means as the water is, which prevents the gases or vapor inside of the tank from catching fire. If the tank does begin to burn from the top, then the oil is pumped from the bottom of the tank into another one, thereby saving a great deal of the oil.

One of the principal and most important positions with any oil company is that of fire marshal. It is his duty to know the position of all the fire plugs, just what connections are to be made, and to take complete charge in cases of fire. Upon this "emergency man" depends the saving and salvation of the oil men.

There are discovered from time to time what are known as freak wells. One in particular is located in Mexico. It was drilled with every indication of producing a big supply of oil. After the nitro had been set off there gushed forth a volume of hot water, mud, stones, and very little oil. The gases in the oil and the force of the explosion caused the opening, which was sixteen inches at the start, to widen out so much that this time it spread over an area of more than forty acres. At the time it spouted, the woods around it caught fire, and many thousands of dollars were spent in putting it out. At this time very little oil is taken from the well, and its spoutings are intermittent.

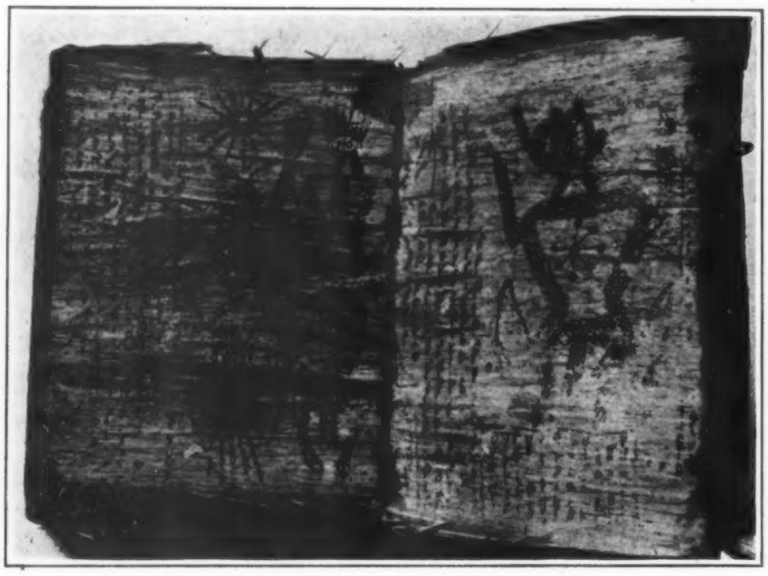
There are many erroneous ideas as to the handling of kerosene and gasoline. It is not generally known that oil, that is, kerosene, is not explosive. A simple experiment can be tried to demonstrate this fact. Place a small saucer of kerosene on a table, and throw a lighted match into it. In every case the oil will put out the light from the match. Gasoline also is not explosive. It is the vapor thrown off from the gasoline that causes the explosion. In the case of kerosene the flame is put out because the oil is cold and there is no vapor. But hold a match to a wick which feeds on oil and you can light the wick. That is because there are but few drops of oil on the wick, which draws more oil when that is exhausted.

The petroleum market has advanced to such an extent that much modern locomotion is now by gasoline or oil. The auto and aero also use gasoline, and where formerly the auto used steam, now, the only article is gasoline.

# The Evolution of the Art of Writing

## Some Forerunners of Our Modern System

### By Dr. Alfred Gradenwitz



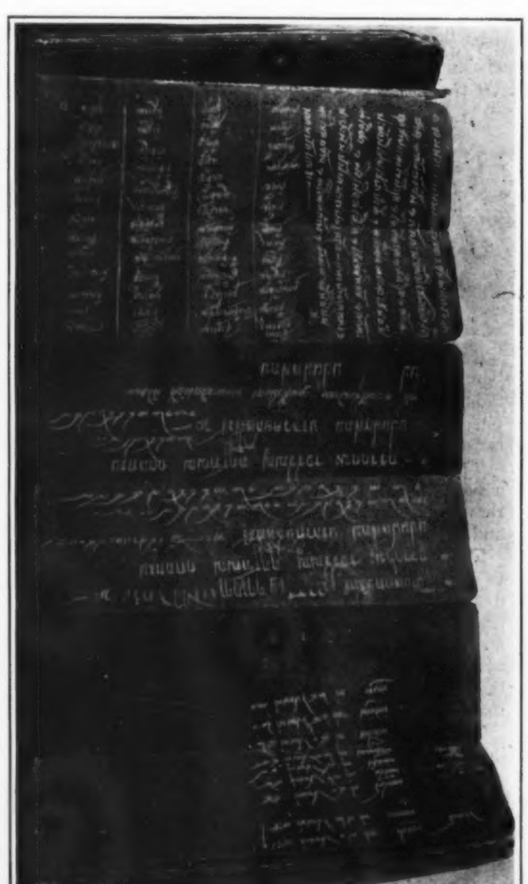
Battak Book Written with Soot Paste on Bark.

Edition de Luxe of the Koran.

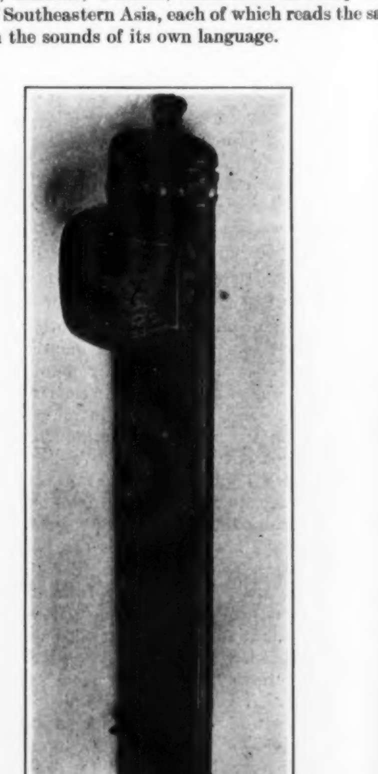
The art of writing, like language itself, doubtless allows the degree of civilization of a people to be gaged, a more elaborate or simplified script being characteristic of a high mental development, while a rudimentary system of writing invariably belongs to a low stage of civilization. Moreover, there is an obvious interaction between language and writing, the latter fixing the former and contributing to its propagation.

In all parts of the earth the most rudimentary means of recording language is a picture-writing which eventually develops to more elaborate systems. This evolution has taken a diametrically opposite course in Europe and the Near East on one hand, and in the Far East on the other. The ancient picture-writing of the Chinese in fact developed to the most admirable ideological script, where each sign stands for a given idea. The many thousands of signs which compose Chinese writing in their turn consist of a limited number of component elements by the combination of which all abstract ideas can be expressed in a most ingenious fashion. Writing thus becomes practically independent of the language it is meant to represent, and as it were constitutes a universal language of its own. In fact, the monuments of Chinese literature on which the civilization of the Far East is based, are equally well understood by the inhabitants of any part of the Celestial Empire, irrespective of its native dialect. Nay, they are read with the same facility by the Japanese, Siamese, Coreans, Annamites and any other nation of Southeastern Asia, each of which reads the same sign with the sounds of its own language.

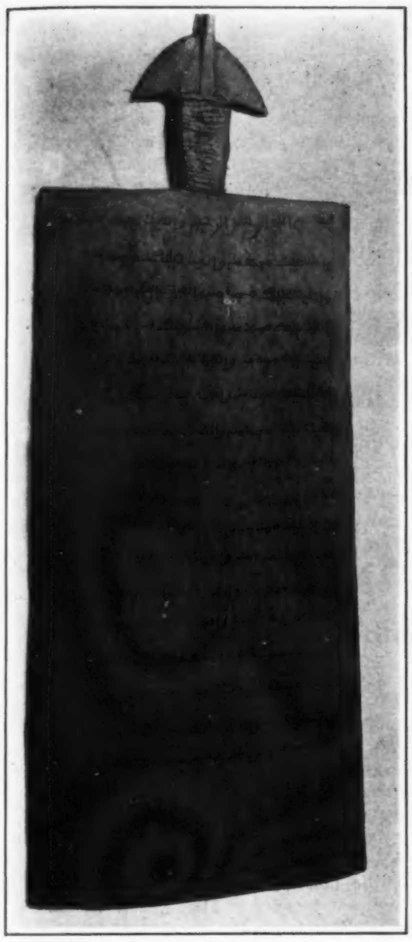
Malacca Bible. Hindoo Script on Bamboo Shavings.



Siamese Book on Slate Paper.

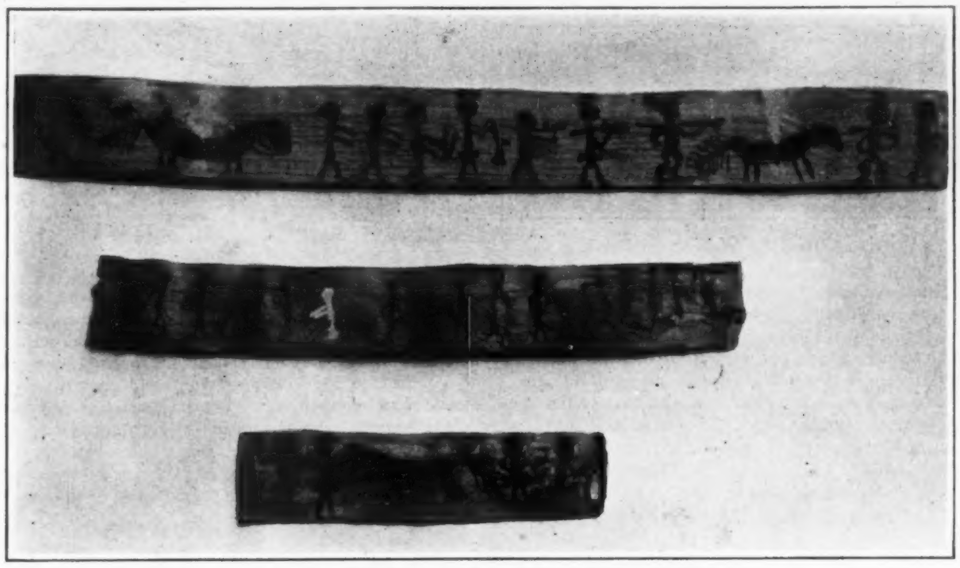


Arabic Pen and Ink Case.



Tablet with Script from Lagos (Africa).

As this elaborate script offers the undoubted drawback of preventing a universal knowledge of the art of writing and reading in all classes of society, the Japanese about (800 p. D) adopted beside the higher literary writing, a simplified syllabic script called Hiragana, which is mainly intended for the use of the illiterate, though a combination of the two systems is frequently found.



Characters Used by the Pangroe Negroes (on Bark).

Our own system of writing can be traced back to the ancient Egyptian hieroglyphs which at first were merely a system of picture-writing. As, however, some hieroglyphs were eventually singled out to designate sounds, the Phenicians, having been taught the art of writing by the Egyptians, gave up the picture-signs proper, adopting only the phonetical characters. These were taken over on one hand by the Hebrews from whose writing Arabic script has sprung forth, and on the other, by the Greeks and from these by the Romans, thus giving rise to the development of occidental writing.

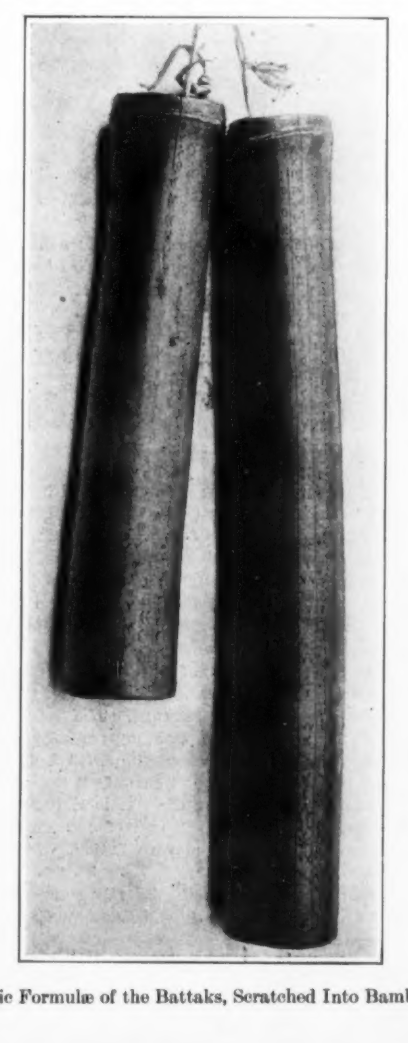
The oldest writing material was stone or burnt clay, in both of which the most important moments in the life of a nation or the individuals were engraved with a view to preserving them to a remote posterity. In Northern Europe the ancient Teutons long used an alphabet of runes, viz., 24 and eventually 16 characters, which originally served for religious purposes, as magic signs on amulets, etc. The signs of Egyptian picture-writing have been preserved in the inscriptions of many stone monuments and especially the obelisks and pyramids where all the more important events of the time have been cherished. The ancient Babylonians, Persians, Medes and Assyrians engraved their wedge-shaped or cuneiform signs in clay, made resistant by burning in a furnace.

Arabic script forms an important group with many varieties in use in all Mohammedan countries in Turkey, on the Nile, in Soudan, East Africa, Persia, Afghanistan, etc. The adherents of the Great Prophet generally write with cane pens called *kalam* (from Latin *calamus*), resembling our old goose-quills, which are kept in a pen-case made of wicker-work or metal with the ink pot attached to it. For the first school instruction primitive wooden tablets strewn with ashes are frequently used, on which the children write with small wooden rods. The wood is frequently replaced by some more resistant material, such as the collar bones of camels, of all things. In India, they also write with a cane style, which is there called *Ru'um;* the point of this style however, is adjusted somewhat differently from the arabic *kalam*, as the Hindus write from the left to the right, whereas Arabic is written inversely from the right to the left.

The Brahmans of India first introduced colored writing (from China) at about 500 B. C. The Hindus originally wrote on the bark of trees, and later on cotton fabrics or Chinese paper, while any especially important documents were fixed on gold or copper sheets. Some rare tribes of Eastern India, e. g., those of Laos, still use a strange kind of engraved script, the characters being carved by means of a metal style into palm leaves or bamboo rods. These letters are sent by special messen-

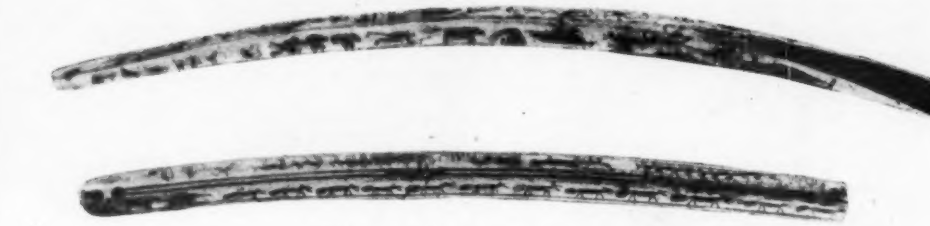
Writing Set of Mohammedan Negroes.

**Camel's Shoulderblade Covered with Arabic Script.**



Magic Formulæ of the Battaks, Scratched Into Bamboo.

Assyrian Cuneiform Writing on Brick.



Diary of Tchuktches Eskimo (on Bone).

gers, who have frequently to travel over great distances, the addressee rubbing the letter in with some dye stuff, so as to bring out the script clearly.

Some strange systems of writing are found among the highly developed Malay tribes in the interior of Sumatra, the Bedjang, Tagals, Bugi and Battaks, that of the last being especially interesting. The Battaks, it appears, had in a remote past received some civilization from the Hindus, and their art of writing, therefore, represents a stage of at least two thousand years ago. This writing is partly a primitive smearing and partly a carving script. In the former case the interior bark of trees or some sort of parchment made from bamboo supplies the writing material, on which a thin soot paste is smeared by means of a palm-tree rod. The carving script is written by means of an iron style engraving the characters into palm leaves, bamboo cane or similar resistant materials.

This primitive writing of the Chinese also was a scratching script, the first attempt to chisel characters into stone after the manner of hieroglyphs, or to engrave them in metal being made between 2,000 and 1,500 B. C. Bamboo tablets were later used to engrave the characters, while in the last centuries before our era, the Chinese began writing with ink and brush, which method they have kept to this very day. In fact, Chinese ink has achieved fame as a product never equalled by any imitation. The Japanese, also write with brush and ink.

Nicely decorated tubes of bamboo or metal, which are frequently artistic master pieces, are used by the Chinese and Japanese as reservoirs for their writing utensils.

# The Theories of World Making*

## A Review of the Earlier and the Most Recent Hypotheses

By A. T. DeLury

On the subject of cosmic theories there appeared within the year lately closed an important work by Poincaré, "Les Hypothèses Cosmogoniques." In this work—a course of lectures to advanced students of the Faculty of Sciences at Paris—the distinguished scientist examines in detail the arguments for, and the objections to, the more outstanding hypotheses that have been formulated. The great value of the book will, I think, be found in the fact that in a matter where scientific judgment and acumen is quite as large a part as positive demonstration, we have presented to us the opinions, the doubts, and the hesitations of one competent in almost unequalled degree to approach the problem. The reading of this work has led me to consider with you this evening certain of the cosmic hypotheses that have most claimed attention.

As the theories will be examined principally in relation to the solar system it may be well to bring together the more essential facts pertaining to that system:

(1) The Solar System consists of a central body, the Sun, and a number of planets, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

(2) The planets revolve about the sun in orbits that are ellipses, the sun being at a focus of each elliptical orbit. The ellipses approximate very closely to circles, i. e., their eccentricities are small.

(3) The planes of the orbits lie close to one another, being inclined at angles not greater than 7 degrees 15 minutes to what will be called the plane of the solar equator. As a phenomenon, the sun and the planets are seen from the earth ever within a narrow belt of the heavens.

(4) The sun rotates on an axis which determines the solar equatorial plane. The planets also rotate and several of them have one or more satellites or moons which revolve about the parent planets much as the planets themselves revolve about the sun. One planet is surrounded by a ring, or rather a set of rings, which revolves about the planet.

(5) The planes of the orbits of these moons are for the most part but slightly inclined to the equatorial planes of the parent planets and to the solar equatorial plane.

(6) The sense of all these movements—with certain exceptions to be noted later—whether of rotations of the sun and the planets, or of revolutions of planets or satellites, is the same, that of west to east in the heavens, as we say.

To these, with a view to definiteness in the image called up, though the facts cited are not without moment to any theory, let us add.

(7) The mean distances of the planets from the sun range from 36,000,000 miles, that of Mercury, to 2,792,000,000 miles, that of Neptune. The volume of the sun is large compared with any or all of the planets; if we call the volume of the earth 1, that of Jupiter is 1,309, the aggregate volume of all the planets is 2,221, while the volume of the sun is 1,310,000. If we call the mass of the earth 1, that of Jupiter is 318, the aggregate mass of the planets is 446, while the mass of the sun is 332,000.

To account for the unity or solidarity suggested by the small eccentricities of orbits, the approach to coincidence of the orbital planes, the uniformity in the sense of motion, many early speculative views were entertained, but we shall pass them by to consider the hypothesis stated first by Laplace in 1796, usually referred to as the Nebular Hypothesis.

It would be interesting and illuminating to quote from Laplace the considerations that led him to entertain the theory that bears his name, as well as his statement of the formal hypothesis, for, very generally, the outlines of his views have failed to present or insist upon certain essential features. Time, however, will not permit this, and I shall have to ask you to be content with a condensed account which will, at least, emphasize the features to which I have referred.

In seeking the veritable cause or source of the phenomena cited, Laplace points out that it must have embraced all the planets, and, distances considered, it must have been a fluid of vast extent. To have imposed an almost circular movement in the same sense about the sun, this fluid must have surrounded the sun, as an atmosphere that must have extended beyond all the planets. Through loss of heat the atmosphere would progressively retire under the action of gravity, and if we suppose it endowed with a motion of rotation, necessarily slow, but as of one mass with the sun, we have a brief statement of the undeveloped hypothesis. The march of the process would be condensation through loss of heat with the necessary increase in rate of rotation, and the reaching of a stage when at the equator the velocity of the particles of matter would be such that the so-called centrifugal force would balance the force of gravity, when zones of vapor would be abandoned. While these zones might be expected to condense into rings, the uniformity which this would demand both in the material of the ring and in the process of cooling would have been rare, the only instance being the rings of Saturn. The disruption of rings would lead to the formation, under attraction, of spheroidal masses with a movement of rotation in the sense of their revolution since the inner molecules had a slower velocity than the outer ones. If one of these masses were sufficiently large, it would attract the others to it to form one such spheroidal mass with the motion of rotation as described. In the smaller planets—the asteroids with orbits intermediate to those of Mars and Jupiter—we have, perhaps, a disrupted ring not aggregated into a single planet. The formation of satellites would be analogous. Inequalities in temperature and density—for there could scarcely have been uniformity in these qualities—would produce the deviations from regularity that appear in the slight eccentricities of orbits and in the slight inclinations of orbital planes. Laplace thought that our system at one time might have presented some such appearance as do the nebulæ which, under the telescopes of the time, suggested, in general, a strong central condensation. Thus to his speculations came to be associated the name Nebular Hypothesis.

This bold and genial theory, commended by the authority of Laplace as well as by what we may call its reasonableness, held almost undisputed sway over the minds of men throughout the greater part of a century. But, very early, difficulties appeared. In the first place, it was not clear that certain phases of development could be justified on dynamical grounds. Again, in time, the telescope revealed striking though not numerous variations from that uniformity in the movements of the planets and satellites which had suggested the hypothesis. Last of all, the advances in the sciences that touch the problem of evolution called for modifications in the presentation of the theory so fundamental that to many it seemed that the hypothesis was ceasing to be itself. The more striking of these difficulties will now be considered.

About the middle of the century, E. Roche, Professor at the University of Montpellier, set himself the problem of giving to the theory of Laplace the precision that comes from a specific mathematical or dynamical treatment and of following it out to its logical consequences. The papers of Roche were published in the proceedings of the Academy of Montpellier; they were given a wider publicity in the great work of Tisserand and now find a clear exposition in the already cited work of Poincaré. It is shown that under the supposition of a strong central condensation and of a movement of rotation by which each particle of the atmosphere is carried, not independently, but as part of a rotating whole made up of sun and atmosphere, the results claimed by Laplace are, in the main, either normal or possible. Gaseous matter would not escape in a continuous stream at the equator, but would be left behind in rings of vapor at epochs and in this regard the supposition of strong central condensation and of uniform motion of rotation as of one body is necessary. The rings abandoned would normally in time become unstable, and under rupture could aggregate into planets, though the time implied in this would be very great. When it came to the abandonment of zones of vapors by the condensing planet, and the advance to the sub-planetary or satellite condition, a new element or influence in the development of a system from the planetary center appears in the attraction of the sun. The action of the sun through tidal distortion and friction would tend to equalize the periods of rotation and of revolution of the planet; later, the planet condensing, the tidal effects would be less and the rate of rotation of the planet would increase. In like manner the satellite would have its two periods tend to equality, and having progressed further in the march of condensation, would be less likely than the planet to experience a later acceleration of rotation. Indeed, the inner planets themselves would seem to have their two periods nearly equal. Thus, in the satellite the conditions would be unfavorable to the formation of an additional series of satellites, and no case of such is known. Roche showed also that, in the rotating mass as postulated by Laplace, there would be a flow of matter, along the surface, from the neighborhood of the poles to the equator, and that this matter, with lower actual velocity than the surface matter near the equator, would tend to become immersed in the atmosphere and form interior rings which would lead to the formation of a planet within the atmosphere. This planet moving within the atmosphere would experience a contraction of its orbit and an increase in the rate of revolution. Another important feature of Roche's work was the establishing of the fact that at a distance from a planet less than two and one-half times its radius a small satellite of approximately the same density would be disrupted.

It is in place now to refer to the work of Sir George Darwin on tidal friction. Laplace and Roche had pointed out certain general results of such action. The importance of tidal friction as an inevitable and power-

* Retiring President's address, annual meeting of the Royal Astronomical Society of Canada. Republished from the *Journal* of the Society.

ful influence in the development of planetary systems is the outstanding contribution of Darwin to the theories we are now considering. He worked out his ideas in a series of papers presented to the Royal Society and in his very interesting work on "The Tides" he has given a simple account of his theory, showing how in particular tidal action must have played a considerable part, and was probably the preponderant influence, in the development of the earth-moon system.

The more important objections to the theory of Laplace will now be considered and the arguments advanced to meet them briefly stated.

(a) Modern science has found it difficult to admit the existence of a gaseous nebula with a high temperature, as was contemplated by Laplace as a primitive form of his solar nebula.

For a long time, to this objection, was urged the fact that the telescope reveals what would seem to be such nebulæ, while the spectroscope presented the bright lines characteristic of glowing vapor. It is, however, now generally believed that the tenuous matter of the nebula exists in some such condition as a gas and that the glow is due to electric excitement.

(b) The time necessary to the evolution offers certain difficulties.

For the aggregation of a disrupted ring into a planet the time demanded is enormous. Yet to this we may say that we have a long past upon which to draw. When, however, we come to the time during which conditions on the earth could be said to allow the existence of water on the surface, or to be favorable to life, there are rival claims for time that may be checked up one against the other. Sir William Thomson and Helmholz, accounting for the greater part of the sun's heat as the equivalent of the mechanical action of shrinkage in the sun, assigned certain periods as limits to such conditions. These seemed inadequate to the demands of geology and biology. But now the later teachings of science show that in the spontaneous changes which radium and other radio-active substances undergo, we have a hitherto unsuspected source of heat, and this will allow an enlargement of the periods assigned by the physicists, ample enough probably to meet the severest demands of the geologist or biologist.

(c) Prof. Moulton and Dr. See are of the opinion, or rather insist, that Laplace's hypothesis is rendered untenable through the consideration that in a body condensing under the action of gravity the law of conservation of areas holds, i. e., as a particle draws nearer the attracting center its velocity increases so as to insure that the area swept out by a line from the center to the particle continues to be the same in any given time. Appeal is made to a paper by Babinet in the *Comptes Rendus*, Tome 52. See speaks of the theory there developed as Babinet's "Criterion." According to Laplace, when the ring which was the source of the earth was abandoned the nebulous mass was rotating in somewhat the same time as that required for the revolution of the earth about the sun. See shows that if the matter now making up the sun, the inner planets and the earth were distributed uniformly throughout the space reaching out to the earth from the sun, the law of conservation of areas would require the period of revolution of the earth to be 1673 years in place of one year, and so striking a discrepancy must rule Laplace's hypothesis out of court.

The objection would seem to be based upon a complete misunderstanding of Babinet's paper and a disregard of the explicit and repeated statement of Laplace that he developes his system from a central condensed sun with a tenuous atmosphere. Babinet's paper would seem to be written to show that an hypothesis different from that of Laplace would lead to just such disagreements with actual facts as See points out.

(d) The rotation of Uranus and Neptune is retrograde, this fact in regard to the former being known to Herschel before Laplace's theory was given to the world, although Laplace would not have been aware of it.

Laplace explained the direction rotation of the planets in the following way. When the ring was left behind it rotated as if it were of one piece, accordingly the outer particles had a greater actual velocity than the inner ones. Hence when the aggregation advanced to completion the outer particles determined by their excess of velocity a direction rotation. Now opinion inclines to the view, that in the gradual disruption and condensation of vapors into particles and masses, the inner masses, moving as independent bodies and not carried as part of a continuous stream, would in their orbital motion about the central attracting mass have a greater velocity than the outer particles and masses, as is required by Kepler's Third Law. Hence under aggregation, the resulting spheroidal mass would have a retrograde rotation. Then tidal action as suggested and explained by Roche and Darwin would bring the period of rotation and that of revolution to equality and to the same sense, i. e., the retrograde rotation would be gradually changed until it became direct. Then under condensation the rate of direct rotation would increase. In the case of the outermost planets the effect of tidal friction would be small and it seems not to have triumphed over the retrograde motion.

(e) In the systems of Jupiter and Saturn the outermost moons revolve in the retrograde sense, while the inner moons have a direct revolution.

Referring to (d) we may say that in the earlier history of those systems, the planets had a retrograde motion, and while this was the case they shed the outer rings, which generated the outer moons and their revolutions would be retrograde. Later when tidal friction had turned the scales, other rings were shed, now with a direct rotation and giving rise to moons moving round the parent planet in the direct sense.

(f) The inner part of the rings of Saturn, as well as the inner moon of Mars, revolves in a period less than the time of rotation of the parent planet.

This is on the face of it at variance with the ideas of Laplace. But we have seen that Roche's investigations pointed to the formation of rings within the planetary atmosphere. It was shown, too, that the orbits of the resultant moons would be contracted and the time of revolution diminished. This may be regarded as an extreme or strained modification of the original statement, yet it is a possible explanation of the difficulty.

(g) The relatively great size of the moon, and, in relation to this, its great distance from the earth, makes it an anomalous element in the solar system. It has been argued that the earth's atmosphere could have reached only three-quarters of the distance to the moon when the rate of rotation gave a period of 27 days 3 hours, the time of revolution of the moon.

This last statement is inaccurate because it is based on the absolute attraction of the sun, whereas, the sun attracting the earth as well, the relative attraction should have been employed; then the difficulty disappears. Further, Darwin's "Tidal Theory" affords a satisfactory, or at least, a possible explanation of the essential facts of the moon.

Time will not permit the consideration of other objections. The more striking of the difficulties connected with the theory in question would seem in some measure resolved. Yet one may well feel that the adjustments have been too numerous and perhaps somewhat artificial. Many have so felt, and have offered theories, with more or less in common with the older hypothesis. Of these the more striking departures from Laplace's theory are those that are associated with the names of Chamberlin and Moulton, and with the name of See.

If the solar system developed along the lines traced by Laplace, we should expect to find, among the nebulæ, many of spherical or lenticular form with strong central condensation, as well as many showing rings more or less complete left behind by the contracting nebula. It has already been said that the testimony furnished by the telescope at the time of Laplace was to this effect. For a long time it was supposed that this type of nebula, if not the prevailing type, was a sufficiently common one to add to the evidence in favor of the generally accepted theory. In recent years, however, all has been changed. With improved telescopes, and more refined methods, particularly along photographic lines, we have learned that everywhere there are nebulæ and that the great majority of those examined are of spiral form. Very few seem to be of a form fitting in with the evolution sketched by Laplace, indeed none with any real measure of certainty. Thus the Andromeda Nebula, which in photographs taken not long ago, appeared as a lens-shaped nebulous cloud, with a well-defined large detached ring, and what seemed to be nuclei for planetary condensation, and afforded the argument of fact to the Nebular Theory, is now thought to conform rather to the spiral type. The evidence from without is accordingly disquieting.

Chamberlin, the distinguished geologist, adding to the more generally known objections to Laplace's theory certain objections reached through considering conditions on the earth, was impressed by the great number of spiral nebulæ, and was led to a theory based on the Planetesimal Hypothesis. He early associated with himself his colleague Moulton, the astronomer. Jointly they have worked out the theory in some detail and there are many points in which, according to general opinion, it is more satisfactory than the older theory.

The spiral nebula is assumed to be the form out of which our system evolved, and in accounting for the existence of the spiral form, Chamberlin finds the clue to the later development, although, it must be said the theory of the development is not necessarily based on the argument concerning the origin of the nebula. He postulates the near approach, if not actual contact of two suns as they move through space. Great tidal distortion and tidal stress are induced in each. If we direct attention to one of suns we see protuberances polar to each other, in the direction of the other sun. Under the stress, streams or masses of matter are ejected, much, if not all, of which is retained by the parent sun as the other moves away. The withdrawing sun, however, imposes upon the streaming or ejected matter on each side a motion in the plane determined by the direction in which it is moving. Thus, when the other sun has moved on, we have a sun with two projecting arms each more or less markedly spiral on account of the motion of rotation imposed in greater degree on the more remote parts. The early condensation of separated nebulous masses in the arms into small planets or into dust or meteoric swarms, and the aggregation of the planetesimals into planets under the action of gravity or through collision at the intersections of orbits would seem to be a normal line of advance. Much of the uniformity that so much impressed Laplace, in the solar system, as the closeness of the planes of the planetary orbits, and the prevalence of direct motions, seems to follow. Yet not a few of the difficulties encountered by Laplace's theory are difficulties in the newer theory. The hypothesis has much to claim our judgment and there are certain terrestrial demands that, as Chamberlin shows, are best met by it. The case is excellently presented in Prof. Chamberlin's well-known work on "Geology" and in the Year Book, No. 3, of the Carnegie Institution. Many papers by Prof. Moulton fortify it on the more purely astronomical side. Necessarily much remains to be done in the way of elaboration, and in the meantime we must see in the hypothesis a bold and original attempt to grapple with a fundamental problem. I shall close this brief sketch of this theory by citing certain facts that involve difficulties. The probability of the disruptive approach of two stars is not high, yet the heavens are studded with spiral nebulæ. Further, where stars are the most numerous, in the region of the Milky Way, these nebulæ are comparatively rare, and where stars are least numerous the density of distribution is highest. Again, the origin claimed for the spiral nebulæ makes it possible that they would occur frequently in pairs which seems not to be the case. Last of all, as Hale remarks, it is strange that the small bodies made up of the projected matter of the sun should remain brilliantly luminous for so long a time; strange too that we do not discover incipient spirals giving a bright spectrum.

Dr. See in his great work, "Researches on the Evolution of Stellar Systems," Vol. II., develops what he calls the Capture Theory. He supposes a sun with an extended rare atmosphere. Into this atmosphere there come, from without, bodies whose motion becomes controlled by the attraction of the sun; they are *captured* by the sun. As they move in their new orbits, they encounter the resistance of the atmosphere, and, as See shows, these orbits will become smaller and more nearly circular. These bodies, with additional matter swept up by them, become planets. Later, when small bodies enter the atmosphere from without, they also start on a planetary career, but See shows that the fate of many of these will be to come under the influence of a planet and form satellites; these are captured by the planet. To explain how it is that in our system the planets for the most part have a direct rotation on an axis, See holds that as swarms of dust collide with a planet the tendency is to give the globe just such a rotation. While the theory accounts fairly for the small eccentricities of the orbits of planets and satellites, it does not seem to suggest why the orbits of the planets should lie closely to one another, nor does his argument touching the direct rotation of planets convince.

The question of the genesis of nebulæ and in particular of spiral nebulæ is also considered by See. He thinks that nebulæ are formed through the assembling of particles of dust driven out from the stars by the pressure of light and by the action of electric forces. The nebula is a colony of such matter, ordinarily not at rest. If two such cosmic clouds drift near each other, the nearest parts might very well, under the action of gravity, come into contact or coalesce. The two clouds would then form one nebula. This contingency is more likely to arise in the case of clouds moving in directions somewhat opposite. After junction the parts that came together would form a nucleus around which the wings, as it were, would rotate in the same sense. Poincaré points out that in this theory of spiral nebulæ there is a grave weakness. There is no reason to assume that the two cosmic clouds are equal in extent or are of similar shape. Yet in actual spiral nebulæ there is a symmetry in the spiral parts for which the origin assigned by Chamberlin accounts.

In respect to the different hypotheses, there now arises the question of the one to be accepted. If we reflect that a theory is less a finality than a unifying or co-ordinating statement, of value mainly as it stimulates intellectual action and leads to wider knowledge, we shall, I think, feel that it is best to keep an open mind toward them all. Indeed, there is little virtue in this choice, for in all of them there are convincing features, in all of them certain points of weakness. In the sci-

ences that have to do with things immediately at hand, and with the actions between them, where we can, as it were, surround the enemy, we know that only the outposts have been taken. Can we wonder then that, in a science in which nearly everything involved is on a transcendent scale, there should be so much withheld? We can, at least, be comforted when we find Darwin hesitating to hold positive opinions, and Poincaré closing his book with the declaration—"Nous ne pouvons donc terminer que par un point d' interrogation."

### Icebergs: Their Size and Characteristics*

NOT infrequently icebergs are miles in extent, and from 2,000 to 3,000 feet in thickness. In some regions they rise above the sea to the height of from 100 to 150 feet and upward, and are some 4,000 feet in circumference; and, as the cubic contents of the part above can scarcely be considered more than one-eighth of that below the water, the cubic contents of the mass may reach to 66,000,000 cubic yards. It is on record that icebergs have been met with of even larger dimensions than this.

On January 5th, 1881, a low-level berg, 15 feet high, and several miles in length, was observed from Cape St. John, Newfoundland. In April, 1882, a steamer was reported to have passed icebergs 1,000 feet long and 500 high; while on May 18th, 1892, an iceberg was passed measuring 600 feet in height and 4 miles in length. An iceberg observed by Sir John Ross and Lieutenant Parry was 2½ miles long, 2¹/₅ broad, and 153 feet high. Assuming the form to have been approximately a cone erected upon an elliptic base, the mass above water would be, roughly, 150,000,000 tons, giving a total mass of nearly 1,500,000,000 tons. This iceberg, however, was by no means of extraordinary dimensions.

In the North Atlantic the distribution of icebergs is very remarkable. Icebergs, of course, can only drift along with some Polar current, such, for example, as the Labrador current, which flows in a generally southerly direction round the coasts of Newfoundland and Nova Scotia. To the east of this track, in which icebergs abound during the early summer months, lies the region which is warmed by the water of the Gulf Stream as it flows to the Scandinavian coast, and here floating ice is rarely seen.

Icebergs move about with considerable freedom. Seldom are two winter soundings alike, and several instances are recorded of places blocked during one winter being quite open the next. There is no infallible method of detecting the vicinity of an iceberg, but it may not infrequently be recognized, even in a fog or at night, by what is known as the ice-blink. This ice-blink, according to the *North Atlantic Guide*, is "a natural brightness, or effulgence, caused by emission of rays of light stored up or otherwise, which frequently renders a berg visible at some distance even on the darkest night. At short distances this effulgence may appear like a white cloud extending over, or nearly over, a vessel's masts. In foggy weather they are seen even through the fog." The temperature of the water is also a means of discovering whether a vessel is in close proximity to ice.

The earliness of the season gave rise at first to the grave doubts as to whether the Titanic could possibly have found an iceberg a little south of the Banks of Newfoundland. In few seasons, however early, has Polar ice passed the Great Banks by the middle of April, and yet there is evidence that during the past week bergs have been seen below the Banks. According to the Imperial Merchant Service Guild, steamers' general reports for the last month were that ice had been seen farther south than in previous years.

The meteorological chart of the North Atlantic for February shows that so early as the second month of the year icebergs were encountered off the coast of Newfoundland out to eastward and some to southward of Cape Race, the southern-most point of Newfoundland. One was seen about sixty miles to the south of the Cape.

Although the presence of icebergs in this locality so early in the season is not unprecedented, it is somewhat abnormal. Bergs may be encountered from March to August within an area reaching out to the point where the meridian of 40 degrees west crosses the parallel of 40 degrees north. This is the average limit, although bergs have been met with to the east and south of this position. In the chart before quoted we read that the risks to shipping from icebergs in the North Atlantic during February was confined to the vicinity of the south-east of Newfoundland. On January 15th a revenue cutter was dispatched to the relief of thirty schooners who were icebound. The Allan liner Grampian also reports having passed a large iceberg on January 8th in latitude 46 degrees 19 minutes north and 53 degrees 50 minutes west. The position of the iceberg encountered by the Titanic was latitude 40 degrees 46 minutes north and longitude 50 degrees 40 minutes west.

That the bergs should cause trouble so early is, notwithstanding, unusual. One theory is that the huge glaciers which fringe the coast of Greenland and Labrador are in a continual state of movement, independent of conditions of the temperature, and, it is argued, quite within the bounds of possibility that one of these glaciers may have come down its steep bed into the sea, impelled by some huge weight of frozen snow on its upper portions, and thus have launched a series of icebergs less high, but none the less dangerous than those that come down from the Polar cap. These may have drifted away on some ocean current, and have found themselves in the track of the Atlantic traffic, south of the Great Banks, which during the summer months are often thickly dotted with Polar ice.

Other causes are assigned for the moving and the breaking away of these huge blocks of ice. One which receives some credit is that subterranean earthquakes have many times been known to cause the currents to deviate from their course, carrying along with them on their new way the deadly bergs. A rise in the temperature through the early arrival of spring will also cause the ice to break away. The year 1911 was a most disastrous one for ice collisions, and navigators became more than usually fearful of the monstrous, slow-moving weights which so often carry death in their train.

* Reproduced from *The English Mechanic and World of Science*.

### Trade Notes and Formulæ

**Pasteboard to Close Cracks in Machinery, Water Pipes, Glass Tubes, etc.**—First prepare a bath as follows: Linseed oil varnish, 7.5 parts; linseed oil, 7.5 parts; umber, 0.45 part, to be heated. Dip the sheets four times successively in this bath; then dip the sheets in a second bath made up of linseed oil, 7.5; siccative, 7.5; turpentine, 1.5; litharge, 0.75, four times, at intervals of twenty-four hours.

**Luminous Wax Beads and Fish Beads.**—*a.* The beads, etc., first blown out with fish scale essence dissolved in gelatine and dried, are blown out with luminous paint that has been mixed with wax, or paraffine, or a quick drying varnish. *b.* The beads, etc., blown out with fish scale essence dissolved in gelatine, are placed in a cylinder containing luminous paint in powder form and exposed, for one to two hours, to a rotary motion to remove the superfluous adhering color, the articles are then placed in a second cylinder, made of bolting cloth, and subjected to a short, supplementary rotary movement.

**Fireproofing of Textiles, Straw, Paper, etc.**—*a.* Sulphate of ammonia, 8 parts; carbonate of ammonia, 2.5 parts, boracic acid, 3 parts; borax, 1.7 parts; starch, 2.07 parts; water, 100 parts. The fabrics are to be immersed in the boiling liquid. *b.* Boracic acid, 5 parts; salammoniac, 15 parts; potash belspar, 5 parts; gelatine, 1.5 parts; paste, 50 parts; water, 100 parts. The mixture to be applied to wood, theater properties, etc., with a brush. Wood-pulp paper, on coming off the machine and before passing to the drying rolls, is to be passed through a solution of 8 parts sulphate of ammonia, 3 parts boracic acid, and 1.7 parts borax in 100 parts of water, at a temperature of 120 deg. Fahr.

**Vegetaline Non-combustible and Impermeable to Fluids** (according to Streubel, Paris).—Over dry cellulose, at a temperature of 60 deg. Fahr., pour sulphuric acid of 58 deg. Bé., allow it to stand for a time, wash out the sulphuric acid in water, dry and grind it. Mix it intimately in a mortar with rosin soap and then add to it a solution of sulphate of alumina. The mixture is dried and formed, under hydraulic pressure, into blocks, cut into sheets and pressed in molds, according to the article to be produced. If the vegetaline is to remain unalterable, the cellulose treated with sulphuric acid, after treatment with water, is washed with salammoniac or borax solution; if it is to be colored, coloring substance is added to the cellulose mass.

**The Making of Copper Stencils.**—To make copper stencils for marking laundry, etc., stencil sheet copper is used (the thinnest that is made) and dipped in a tin dish containing melted bees' wax so that both sides will be evenly covered with a thin coat of the wax. The monogram, device or figure is then drawn on ordinary white paper, the reverse side of the paper is blackened with graphite, and it is laid on the center of the stencil plate and by means of a blunt needle the design is lightly traced. The design will now be visible on the thin wax coating. With the same blunt needle or point trace the monogram, but not completely, the lines being interrupted at regular intervals, to form "holders," so that after etching the monogram cannot fall out. Then the stencils are laid in a dish, fresh nitric acid poured over it, and the air bubbles removed with a goose feather. In barely half a minute the monogram will be eaten through. This may be observed by holding the stencil up to the light. It is then rinsed off with water and the wax coating removed by heating and wiping it off with a cloth. Any wax remaining can readily be removed with the aid of benzine or petroleum.

### Erratum

WE wish to draw the attention of our readers to an unfortunate error on page 298 of the SUPPLEMENT. In Dr. Campbell's article on Stereoscopic Vision, the captions of Figs. 1 and 2 are misplaced, and to correct them the caption under the left-hand illustration must be referred to the right-hand drawing, and *vice versa.*

### Science Notes.

**The Influence of Telephone Lines Upon Lightning.**—An inquiry conducted by Mr. Langbuck in Prussia leads him to the conclusion that within recent times there has been a remarkable decrease in the number of accidents due to lightning in certain cities. He attributes this effect to the extended development of aerial telephone lines, and concludes that inasmuch as at present the practice of laying underground telephone lines is becoming more and more prevalent, we must expect an increase in the number of strokes of lightning.—*Cosmos.*

**The Smallest Dynamo in the World.**—Among the many items recorded in the *Jahrbuch der Naturwissensdraften* for 1910-1911, we read that there was exhibited before the French Academy of Science a dynamo, the total weight of which was only 7 grammes, about 1/5 of an ounce. This little machine, which measures 15 millimeters (0.6 of an inch) in height and length, and a little short of this in breadth, has, of course, only a diminutive output. The diameter of the armature is 6.2 millimeters, and it and the magnet are wound with silk-spun wire 0.05 of a millimeter thick. The total length of the field wire is 1.67 meters. All the parts can be taken apart, being joined together by small screws, not otherwise permanently fastened together. The collectors and brushes are constructed exactly as in large dynamos. The little machine can operate not only as a generator, but also as a motor. In the latter case a small pocket battery suffices to furnish the current. When the motor is allowed to run without a load it gets up a very high speed and makes a humming noise like some large insect. The current consumption is about 2 amperes at 2.5 volts.

**Industrial Uses for Sugar.**—In France efforts have recently been made to increase the consumption of sugar, in order to meet the new conditions which have arisen, owing to the abolition of the premium on importation. As a result of this, an immense increase in the industrial consumption of sugar has taken place. Thus, for instance, while in 1904 the total consumption of sugar in breweries in France amounted to 11,940 kilogrammes, in 1910 the figure was increased almost one hundredfold to 1,152,843 kilogrammes. The increase is even greater in the case of denatured sugar (that is to say, sugar to which salt or other material has been added), which is used for feeding cattle. In 1904 1,122 kilogrammes of this were used. Three years later this had risen to one thousand times the original figure. As a matter of fact, many more industrial uses for sugar could be found. Sugar is not only an excellent food material, it is also an antiseptic, which might be used for preserving butter, condensed milk and wood; it is absorbent for lime and could, therefore, be used for purifying phosphatic chalk, zinc mineral, etc. It is a reducing agent which may be used in indigo dyeing, or it may serve to precipitate the oxide in a preparation of chrome leather. Lastly, sugar forms the raw material for the preparation of lactic and formic acids, of certain cements, soaps, inks, show blacking, etc.—*La Nature.*



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